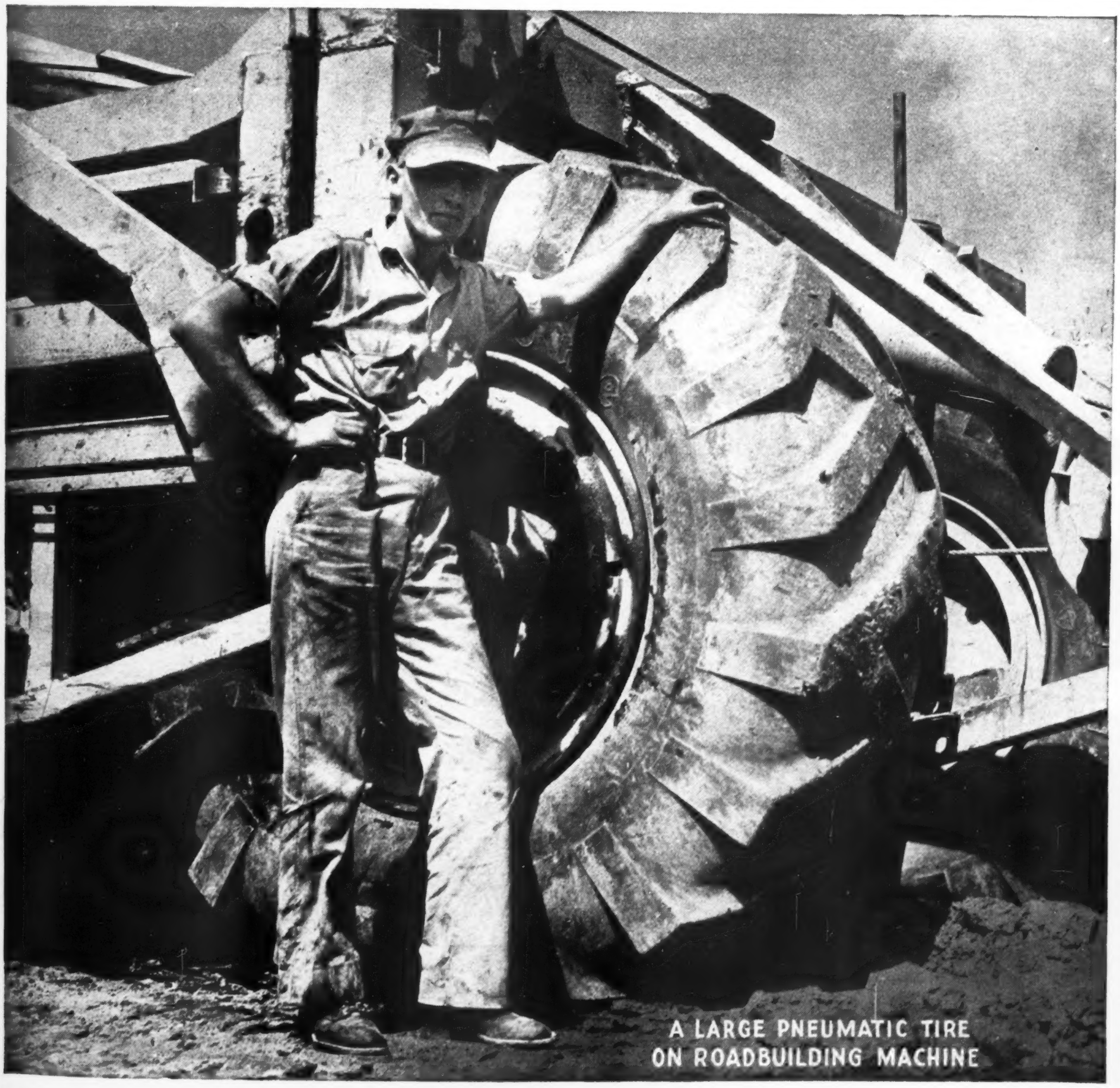
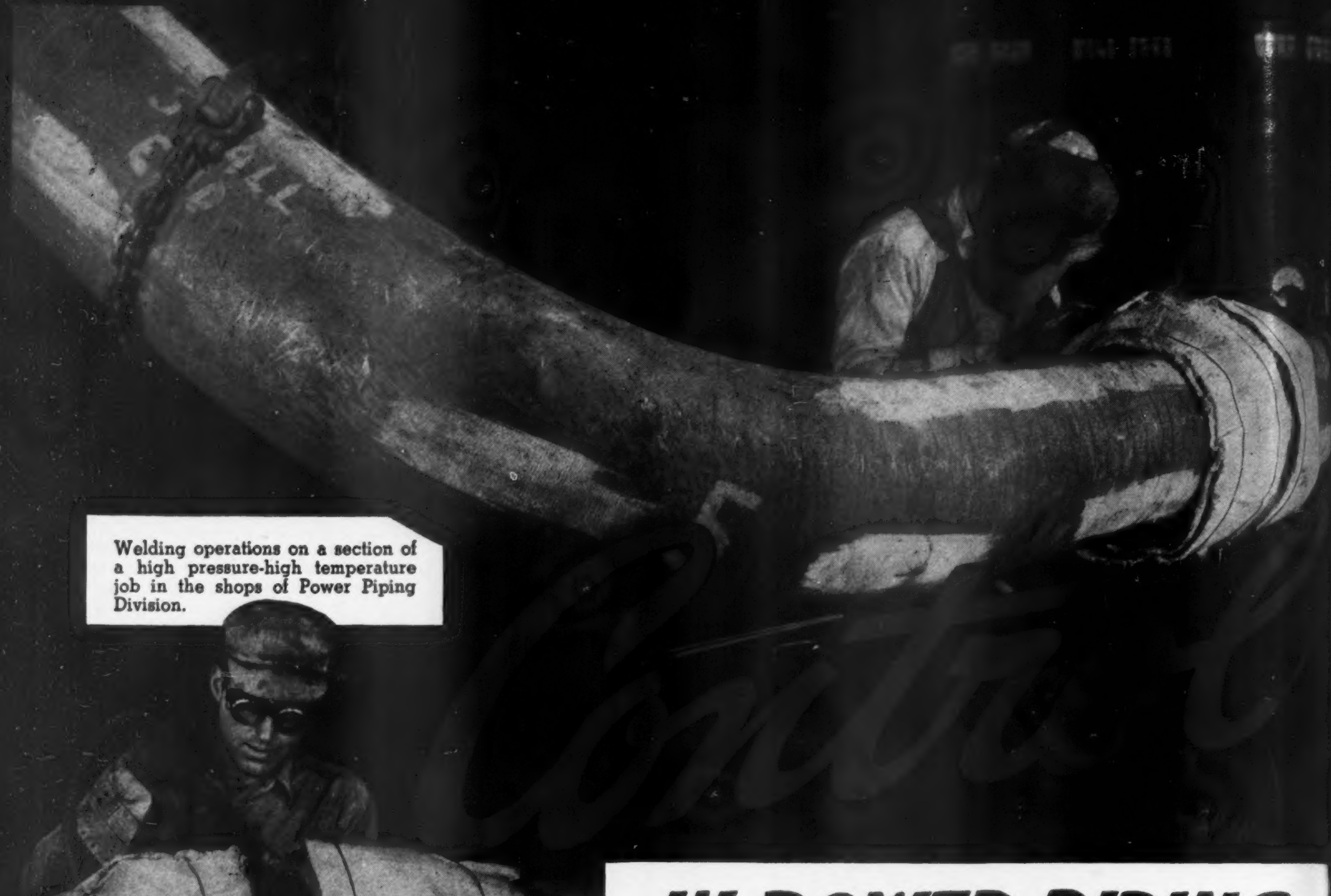
Compressed Air Magazine

Vol. 45, No. 3 London - New York - Paris March, 1940



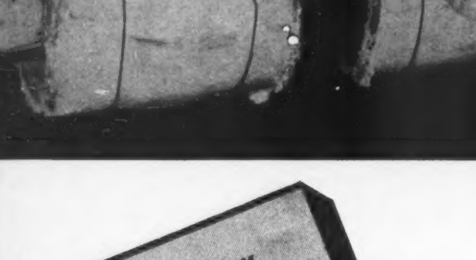
A LARGE PNEUMATIC TIRE ON ROADBUILDING MACHINE



Welding operations on a section of a high pressure-high temperature job in the shops of Power Piping Division.

IN POWER PIPING FABRICATION

All processes in the pre-fabrication of piping by Power Piping Division are accompanied with the proper scientific control necessary to meet the most critical interpretation of current specifications. Such engineering procedures, established by long experience, insure customer satisfaction and confidence.



Control for the work includes where specified:

CONTROL IN BENDING.
CONTROL OF ANNEALING.
CONTROL OF GRAIN SIZE.
CONTROL OF HEAT MAINTENANCE DURING WELDING.
CONTROL OF STRESS RELIEVING.
X-RAY INSPECTION.

BLAW-KNOX COMPANY
POWER PIPING DIVISION

1525 Pennsylvania Ave. Pittsburgh, Pa.

ON THE COVER

OUR cover picture shows a tire on one of the earth-moving machines used in building the Pennsylvania Turnpike. It is 6 feet 7 inches in diameter and sells for $2,278. Huge though it is, this tire is exceeded in size by some now being regularly produced. The Firestone Tire & Rubber Company is turning out tires up to 9 feet in diameter. Despite a load-carrying capacity of 20 tons each, these tires require only 35 pounds of air.

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IN THIS ISSUE

THE article entitled *Oil For Your Automobile Engine* tells the story of Pennsylvania petroleum. Once eagerly sought for its kerosene content, it is now prized chiefly for its content of lubricating oil. Nature was bountiful in creating it. She not only endowed it generously with the hydrocarbons that go to make up lubricating stock but also thoughtfully left out compounds that would complicate its refining. How one prominent refining company subdivides this petroleum into lubricating oil and various other marketable products is set forth in our first eight pages.

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THE article on *Steam Condensers* will appear in three parts. The purpose of its author, A. D. Karr, was to remove from the mind of the layman the mystery that shrouds condensers. To this end he has used primer methods—plain, everyday words, simple sketches, and ordinary arithmetic. Undoubtedly there is need for a lucid explanation of the functioning of such an important and widely used piece of industrial equipment; and both technical and nontechnical readers should find this and the succeeding articles of interest and value.

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MONTANA'S road markers are more than a record of local history. They are a colorfully written compilation of interesting facts, a source of entertainment as well as education. Tourists like the lighter touch, and only the most hurried fail to stop and read. Other states might perhaps do well to make their markers a little less solemn.

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A CORRECTION

IN THE January, 1940, issue, under the heading of *Industrial Notes*, we mistakenly referred to Apexior as a new protective coating for the steam and water contact surfaces of feed-water heaters, deaerators, steam boilers and turbines, etc. This material has been manufactured by The Dampney Company of America since 1921.

Compressed Air Magazine

Volume 45 **MARCH, 1940** **Number 3**

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EDITORIAL CONTENTS

ADVERTISING INDEX

A monthly publication devoted to the many fields of endeavor in which compressed air serves useful purposes. Founded in 1896.

CCA Member Controlled Circulation Audit.

Published by Compressed Air Magazine Company. G. W. MORRISON, president
J. F. KENNEY, vice-president; F. E. KUTZ, secretary-treasurer.
Business, editorial, and publication offices, Phillipsburg, N. J.
Advertising Office, 11 Broadway, New York, N. Y.
Annual subscription price: domestic, $3.00; foreign, $3.50. Single copies, 35 cents.
Compressed Air Magazine is on file in many libraries and is indexed in Industrial Arts Index.

DUBBS CRACKING UNIT

Here, by means of heat and pressure, unmarketable products of the primary refining operations are largely converted into gasoline. The reaction consists of breaking up or cracking large hydrocarbon molecules into smaller ones having reduced boiling points.

McKEAN PLANT, QUAKER STATE OIL REFINING CORPORATION

The McKean refinery, pictured at the right, is located at Farmers Valley, Pa., and is the largest of four operated by the company. It was built in 1921 and has been consistently improved and enlarged by adding new equipment to keep abreast of the betterments in refinery practice. The plant can treat 4,500 barrels of crude oil daily. It obtains its water supply principally from wells that can provide 2,500 gpm.

Oil for Your Automobile Engine

C. H. Vivian

FOR several years prior to 1850, one Samuel B. Kier produced salt by evaporating water from wells that he drilled at Tarantum, Pa., a few miles from Pittsburgh. One well began to deliver oil with the salt water, and in 1849, Kier gave some of it to a chemist for analysis. The chemist reported that the fluid could be satisfactorily used as an illuminant, so Kier began refining and selling it, along with lamps in which to burn it. It was called Seneca oil; and in some unrecorded manner it obtained a standing as a cure-all for human ailments. From 1850 to 1855, Kier sold all that he could produce at from $1 to $1.50 a gallon.

Kier's success influenced other men to search for oil. Among them were George H. Bissell, J. G. Eveleth, and a man named Reed. Learning that oil exuded from springs that fed a creek near Titusville, Pa., they bought 100 acres of land there and leased an additional 112 acres for a period of 99 years—all for a consideration of $5,000. They formed the Pennsylvania Rock Oil Company and started operations. To increase their yield, they trenched the land in the vicinity of the springs until they struck ground water. This, together with the water from the springs, was pumped into pits and vats, and the oil that rose to the surface was skimmed off. The quantity of oil obtained was so small, however, that the venture is said to have been unprofitable.

In the spring of 1855 samples of the oil were submitted for analysis to Prof. B. Silliman of Yale College, who rendered a report in which he foresaw many valuable uses for such oil and even anticipated processes of refining that were later developed. Having seen some of Kier's operations near Pittsburgh, Bissell advocated drilling a well in search of the source of the oil seeps; but there seem to have been objections to that from some of the other stockholders. As a way out of the difficulties, another company, called The Seneca Oil Company, was formed and was granted a lease by the parent concern.

Col. Edwin L. Drake, who was not a colonel but a retired railroad conductor, was employed to drill a well. He arrived in Titusville from Erie on May 15, 1858, with his wife and two children and engaged board and lodging at the town's leading tavern at the impressive rate of $6.50 a week for everything. It was recalled by some of the townspeople that he had visited Titusville about five months previously and had carried away with him samples of the oil that flowed out of the ground near the Brewer & Watson sawmill a short distance below town on "Oil Creek."

The natives openly ridiculed Drake's scheme to drill into solid rock for oil and dubbed it "Crazy Drake's Folly." Unperturbed, Drake went ahead with his plans, and by the following winter he was ready

FRACTIONATOR AND STABILIZING TOWER

These structures are parts of the processing equipment of the cracking unit in which some of the products of primary distillation are converted into gasoline.

to start drilling. However, many difficulties beset him. The first drilling crew that he hired failed even to put in an appearance. Drake went to Pittsburgh to consult Kier, and upon the latter's recommendation employed "Uncle Billy" Smith and his two sons who were experienced drillers for salt. They came to Titusville with a full set of tools about the middle of June, and work got underway soon afterward. Even this pioneer effort had some points in common with modern drilling. Casing was put in place by the simple expedient of driving it into the ground a distance of 36 feet, and then drilling was done inside of it. For power there was used a small steam engine, probably of 4 or 6 hp.

Progress was slow, but on the afternoon of August 27, 1859, the tools dropped into a crevice at a depth of 69½ feet and the rig was shut down for the day. Returning the following morning, Uncle Billy found the hole partway filled with oil. He fashioned a bailer from a piece of waterspout and some string and hoisted some of the fluid to the surface by hand. A few days later a pump was set up, and the well produced at the rate of 25 barrels a day. Kier contracted to buy up to 1,000 gallons a week of the output at 60 cents a gallon. Drake's well precipitated a rush of humanity into the area, and it was not long before drilling derricks were springing up in great numbers. The ensuing boom rivaled any experienced since then in oil fields or mining camps.

More than 80 years have elapsed since Drake brought in the first well. During the intervening period hundreds of oil fields have been discovered in the United States. Some of them have not yet reached their peaks, and many of them that have are still important: but numerous others have been worked out and are now all but forgotten. Meanwhile, the region surrounding the first well—its various producing areas are now collectively known as the Appalachian oil fields—continues year after year to maintain an enviable position in the oil industry. Although not sharing the spectacularity of some of the flush, producing western fields, nevertheless it still commands the respect of the oil world by reason of the high quality of its output. Curiously enough, the oil seeps on the banks of Oil Creek led the first drillers to tap what is up to now Nature's choicest oil storehouse.

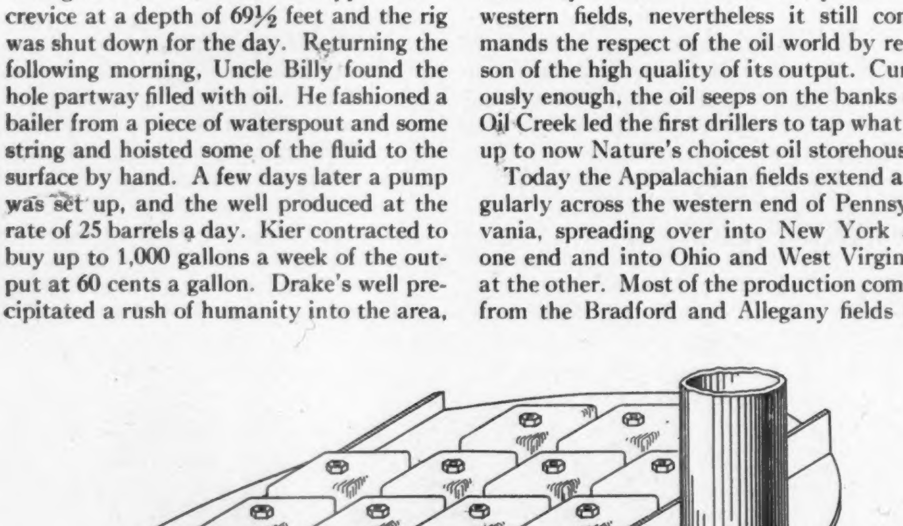
Today the Appalachian fields extend angularly across the western end of Pennsylvania, spreading over into New York at one end and into Ohio and West Virginia at the other. Most of the production comes from the Bradford and Allegany fields in the northern section of Pennsylvania; but the entire area yields what is known as Pennsylvania grade crude oil. That it is a superior substance is attested to by the price it commands.

The development of the Appalachian oil fields has been closely related to the introduction and widespread utilization of two types of mechanical engines—steam and gasoline. The adoption of steam engines as prime movers by the world's great industries around 1850 stimulated a search for suitable low-cost lubricants. Whale and other animal oils were used at first; but as they were also burned in lamps, the supply was not sufficient to meet the demand and the price rose precipitously. This led to a seeking for substitutes, and oil began to be manufactured by the distillation of cannel coal, bituminous shales, and the mineral albertite, which was found principally in New Brunswick. The discovery that the oil that bubbled up from the ground with spring water in western Pennsylvania was of the same character as these artificial oils quickened the quest for its subterranean source.

Because of its origin it was known as rock oil, which is the literal meaning of petroleum, from the Latin *petra oleum*. The first refining practices were crude but adequate, for about the only products sought at that time were kerosene for lamps and heavy lubricating stock for steam engines. Gasoline was a waste product, and most of it was burned or allowed to flow away. With the advent of the gasoline engine, the situation gradually changed; and as automobiles increased in number, gasoline became decidedly valuable. In fact, taking the oil fields of the nation as a whole, gasoline, considered from a monetary standpoint, is today the principal derivative of petroleum. This is not true of the Appalachian fields, however, which have benefited chiefly by supplying lubricating oil for gasoline engines rather than fuel with which to operate them.

Petroleum from the Appalachian fields contains an unusually high percentage of saturated hydrocarbons, and it is largely for that reason that the lubricating oils derived from it stand up well under the heat and friction of high-speed automobile engines. Another advantage is the comparative freedom of the petroleum from impurities such as sulphur, nitrogen, and oxygen. Because these are present in insignificant amounts, it is much easier to eliminate them during the refining process than it would be if the petroleum were less pure.

It is claimed that about one-fourth of the motor cars in the United States are lubricated with Pennsylvania grade oil. To supply this, as well as the associate products, there was taken from the wells in 1939 approximately 27,000,000 barrels of petroleum, or an average of 73,750 barrels daily. Between 65 and 70 per cent of this came from the Bradford and Allegany fields. During the final five months of 1939, even



BUBBLE-TOWER TRAYS

The bubble tower for separating the various component products of petroleum is a remarkably efficient structure. The hot vapors from a still rise through a series of trays and countercurrentwise to a descending liquid, which is usually cold gasoline. Each tray is perforated in a number of places and into each opening is fitted a small nozzle. The latter is surmounted by a bubble cap of such design that the vapors must pass through the liquid reflux in the tray. As they come in contact with the reflux, the heavier vapors are successively condensed and the lighter ones continue to rise. The gasoline vapors, however, are so light that they pass through all the trays and out of the tower top to an outside condenser. The drawing shows details of the construction of the bubble trays.

though refinery operations were stepped up to the highest rate in recent years, it was not possible to meet the demand for lubricating oil, and the deficiency had to be made up from stock in storage. Estimates place the 1940 demand for crude oil at 77,500 barrels a day; and as most of the increase will have to be supplied by the Bradford and Allegany fields, it is expected that 300 new wells per month will have to be drilled in the former area and 100 in the latter—a total of 4,800 as compared with 2,847 in 1939.

The process of refining the petroleum is fundamentally the same as that now in universal use; but because of its purity and inherent favorable characteristics, some of the steps ordinarily required can be omitted. For instance, treatment with strong chemicals to remove sulphur and other impurities is not necessary, and lubricating oils made from Pennsylvania grade petroleum therefore cannot fall heir to the undesirable qualities that such a treatment sometimes produce. Refining practices vary somewhat among particular plants, but the essential phases are generally similar.

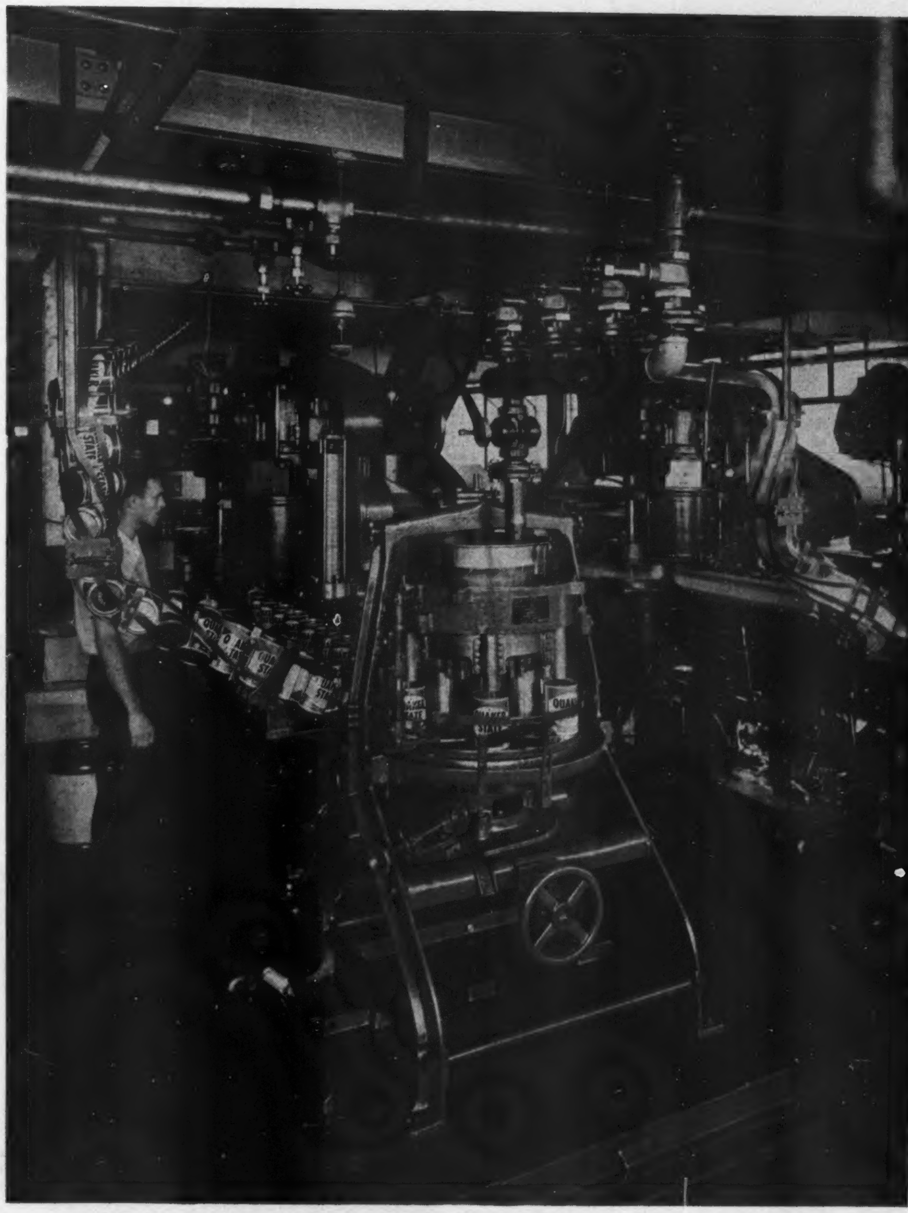
The accompanying illustrations show some of the equipment used at the McKean plant of the Quaker State Oil Refining Corporation, and the remainder of this article will be devoted to a description of the activities there. The refinery is the largest of four that are owned by Quaker State, and is located at Farmers Valley, Pa., about 15 miles from Bradford. The others are at Oil City and Emlenton, Pa., and at St. Marys, W. Va.

The company began operations in 1913. The immediate objective of the management was a lubricating oil suitable for use in the Franklin air-cooled automobile that was then becoming popular with motorists. As the Franklin engine relied solely upon air to carry away the heat of combustion, it subjected the oil to higher temperatures than had been encountered previously in conventional water-cooled engines, and consequently required a superior oil that would withstand the heat and other severe service conditions. The efforts that were made to provide a satisfactory lubricant for the purpose were successful. Since that time Quaker State motor oil has been consistently improved, and it is now recognized as one of the highest-quality products of its kind. It is sold in all parts of the world.

Inasmuch as lubricating oil is the most valuable product of the refining process, everything is done to extract as much of it as possible from each barrel of petroleum, and the greatest care is taken during its processing to preserve its natural, desirable qualities. However, even though Pennsylvania grade crude oil is richer in this respect than most petroleums, the average barrel will yield only a little less than 22 per cent, or around 9 gallons, of lubricating stock. Accordingly, other derivatives are not slighted, and a full list of them is made.

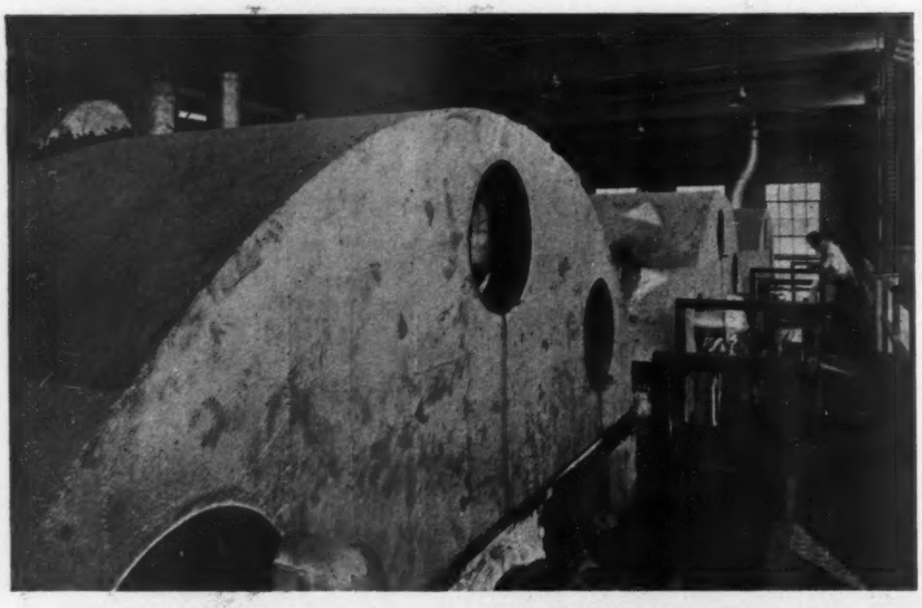
The McKean refinery has a capacity of 4,500 barrels of crude oil daily. This is received from wells of the area through 125 miles of main and gathering pipe lines. Primary distillation consists in preheating the petroleum in heat exchangers to approximately 300°F., and then increasing its temperature to about 650° in a continuous-type, atmospheric-pressure pipe still. The lighter fractions are vaporized, while the heavier ones remain in liquid form. Both the vapors and the liquid then enter a fractionating unit or bubble tower—a cylindrical, vertical steel vessel containing a series of trays. On the upper surface of each tray are numerous bubble caps. These are small, cuplike metal pieces with slotted edges. Each is fixed, in inverted position, directly over a vapor nozzle that rises from a perforation in the bubble tray.

The charge of vapors and liquid enters the tower at a point considerably above its base. Cold gasoline, or reflux, is pumped into the top of the tower, covers the top tray, overflows down to the next one, and so on until all the trays contain a quantity



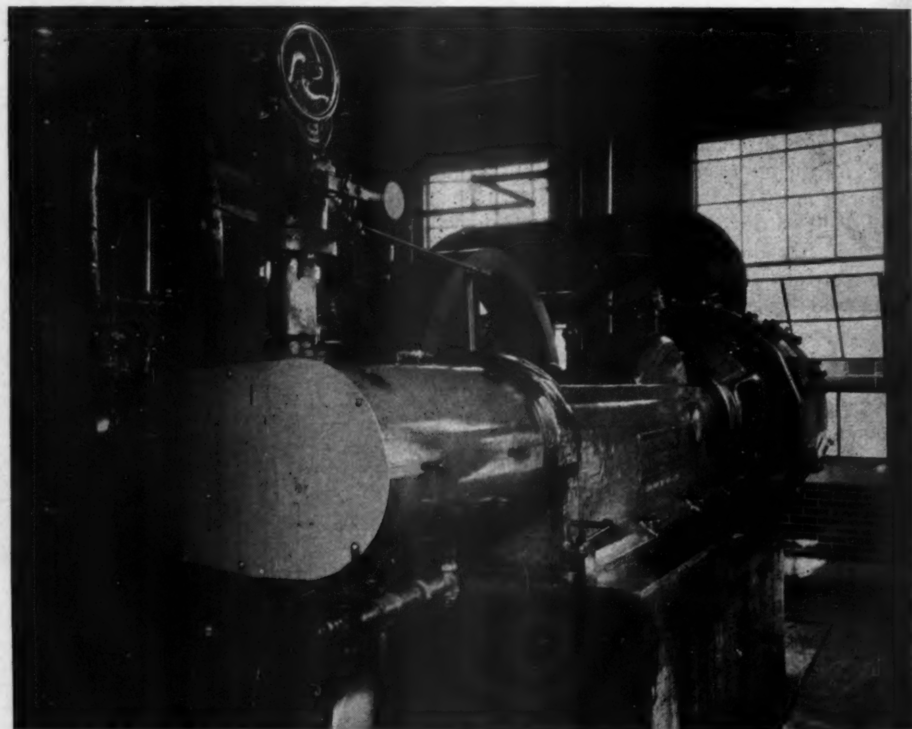
CANNING MOTOR OIL

This is reputed to be the fastest canning plant in existence, each of the two machines having a capacity of 144 quart cans a minute. The cans, in cartons, are delivered from railroad cars by a conveyor belt to the floor above. There they are unpacked and placed on the gravity chute shown at the left—the cartons going by way of a gravity slide to another part of the canning floor. The cans are automatically fed on to a revolving turntable, each one taking its position beneath one of the six vertical pipes through which the precise amount of oil to fill it is introduced. At the far side of the turntable the cans are automatically capped, and from there they pass on to a conveyor that carries them to a station where an attendant packs them in a carton. These are automatically sealed and properly imprinted on the outside to indicate their contents. The oil is marketed only in refinery-sealed containers, being put up in 1- and 5-quart cans and in drums holding 15, 35, and 55 gallons each. The drums are emptied through a pipe that extends to the bottom and that has a check valve on it to prevent refilling.



VACUUM FILTERS AND PUMP

Lubricating oils are made from wax distillate and cylinder stock, the two heavier fractions or cuts of crude oil that are obtained from primary distillation. Both of these contain wax, which would reduce the fluidity of the finished oils at low temperatures if it were not removed. The dewaxing is done in the continuous-type, rotary-drum vacuum filters shown above. There are three of these units in service with 375 square feet of filter area each, and another with 500 square feet is being set up. Solvents in which the oil remains soluble at low temperatures but in which the wax is insoluble are added, and the solution is chilled by refrigeration before it goes to the filters. When suction is applied to a unit, the oil passes through the drum while the wax cakes on its outer surface and is scraped off and removed. These filters are served by the Ingersoll-Rand Type XPV-1 dry vacuum pump illustrated at the right. As the underlying soil is gravel, it is mounted on a 14½-foot floating concrete foundation.



of the liquid. The vapors, entering the lower part of the tower, have sufficient pressure to force their way successively up through the overhead trays, each time passing through the contained reflux. The heavier vapors condense at lower levels, while the lighter ones continue to rise.

Gasoline does not condense in the tower but passes out through the top in vapor form and is condensed outside of it. The vapors that do condense in the tower yield fractions or cuts of naphtha, kerosene, gas oil, and wax distillate, and these are drawn off from the sides of the tower at successive levels and from the top downward in the order in which they are named. Although naphtha is given as a separate product, enough of it is ordinarily made for plant use and it can therefore be considered as a part of the kerosene cut.

The heavier portions of the crude oil, known collectively as cylinder stock, do not vaporize. From the level at which they enter they flow down over the lower-lying bubble trays. Superheated steam is introduced into the bottom of the tower and passes through the trays countercurrentwise to the descending liquid, extracting from it the lighter products. In refining other crude oils it is the common practice to vaporize the entire bubble-tower charge; but this is never done with Pennsylvania grade crude oil. Extremely high temperatures are avoided in order to prevent breaking up the hydrocarbon molecules of the cylinder stock and thus destroying the stable, saturated pattern of their composition.

The various fractions or cuts are now ready for further processing. At this stage they represent approximately the following percentages of the original crude oil: Gasoline, 33; kerosene, 15; gas oil, 8; wax distillate, 25; cylinder stock, 18.5. However, these percentages will not prevail in the end. While some of the fractions require chiefly purification, others still have to undergo transformation.

The gasoline that is the product of primary distillation is known as straight-run gasoline. It contains hydrogen sulphide and mercaptans of sulphur and must be treated to render it "sweet." These substances do not detract from its value as a motor fuel, but they impart an objectionable odor to it and to the exhaust gases of the engine in which it is burned. The hydrogen sulphide is removed by washing with caustic soda, and the mercaptans are converted into compounds without odor by treating the gasoline with a so-called "doctor" solution of lead oxide in caustic soda. The resultant gasoline is satisfactory for use as a motor fuel, except that it has poor antiknock qualities. To improve it in this respect it is blended with other gaso-

lines that are obtained in two ways, which will be described later.

Kerosene, now as in the past, is used principally for burning in lamps; but as the supply exceeds the demand, any that cannot be sold serves as cracking stock in making gasoline. Kerosene that is marketed is purged of impurities by washing it with caustic soda and then with water. All the gas oil is cracked into gasoline. The lubricating oil is obtained from the two remaining fractions—wax distillate and cylinder stock.

Wax distillate is a mixture of wax, gas oil, and neutral oil. The first step in purifying it is the removal of the wax. This is accomplished by diluting the distillate with a liquid in which the oil is soluble but in which the wax is insoluble at low temperatures, so that by chilling the solution it is possible to extract the wax. The solvent used is a mixture of methyl ethyl ketone, benzol acetone, and toluene. The extent to which the diluted distillate is cooled depends upon the pouring temperature desired for the finished oil, and to that end a differential of about 15°F. has been established. That is, if the finished oil is to pour freely at 20°, the solution will be chilled to approximately 5°. Temperatures as low as −28° are required when making motor oil for winter use.

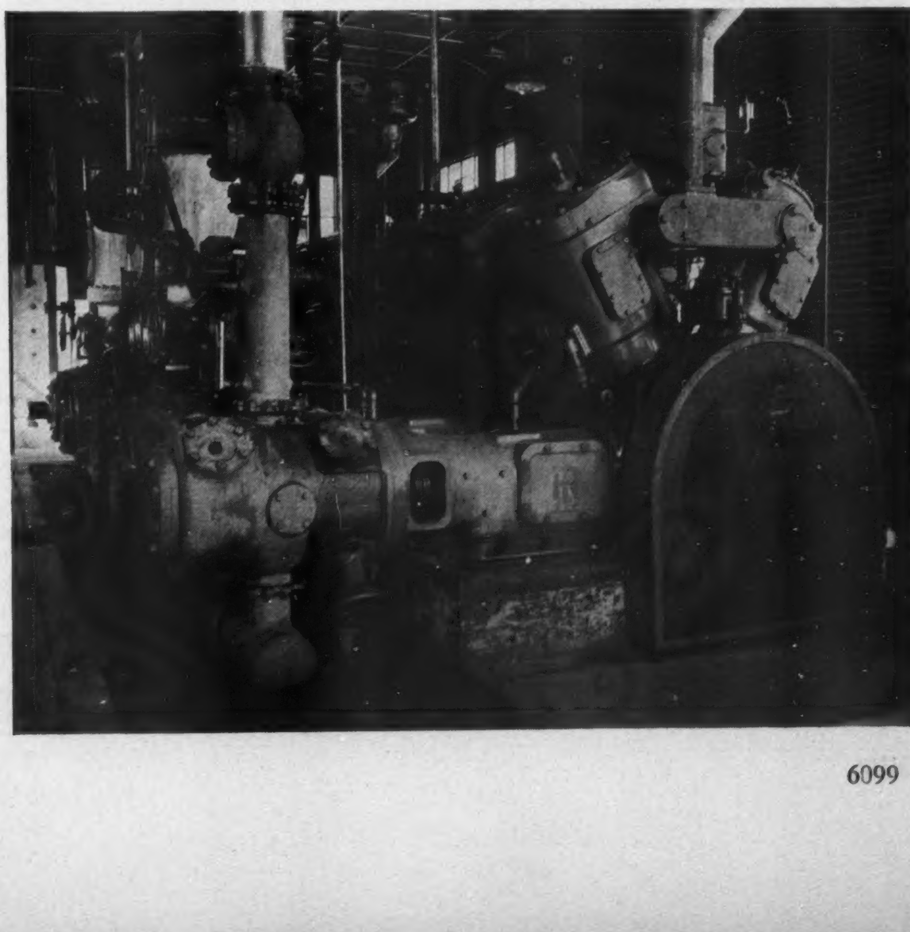
The removal of wax from motor lubricating oil is a very important function because of the resultant improvement in the viscosity index, which is a measure of the fluidity which the oil will retain throughout the entire temperature range to which it will be subjected in an engine. A high viscosity at low temperature retards the flow of oil when the engine is cold, while too low a viscosity at the normal operating temperature may provide a film of oil that is not sufficient to prevent metal-to-metal contact. It also makes for greater power consumption owing to increased friction. Wax in itself is not harmful when the engine temperature is high enough to keep it dissolved—in fact, it may even be beneficial. But at low temperatures it congeals, causes a loss in the fluidity of the oil, and interferes with the starting of the engine. By the old method of removing wax the oil was allowed to stand in tanks in winter, when some of the wax would settle to the bottom. This was replaced by filter-pressing, and then by centrifuging a distillate-naphtha solution. Still newer solvent-extraction methods, such as the one under consideration here, have made it possible to reduce the necessary differential between the pour point of the oil and the chilling temperature.

Equal parts of distillate and solvent are first combined, and then the solution is precooled in heat exchangers by chilled oil returning from the dewaxing equipment. The subsequent cooling that has to be done to give it the final temperature is effected by ammonia refrigeration. The chilling mechanism consists of a number of pipes in series, each jacketed by a larger pipe. The solution flows through the inner pipes inside each of which there is a screw conveyor that is driven by chain sprockets and forces the congealed wax along, together with the solution, to prevent it from adhering to the pipe walls. Liquid ammonia is introduced into the annular space between the two pipes, where it expands and absorbs heat from the distillate-solvent solution. Additional solvent, chilled in the meantime by expanding ammonia in shell-and-tube-type coolers, is added to the distillate-solvent mixture when the latter leaves the series of tube-to-tube coolers and passes to dewaxing filters. At that stage the solution contains five parts solvent to one part wax distillate.

The refrigerating plant is a combination absorption and compression system. Absorption equipment was installed to improve the over-all plant efficiency through the utilization of exhaust or waste steam, which is the principal source of energy of all refineries. A compression system was added in 1937 to provide greater refrigerating capacity. It consists of two Ingersoll-Rand Type 6-XVG machines with gas-

AMMONIA COMPRESSORS

Dewaxing of lubricating oil necessitates chilling it to low temperatures, and this is accomplished through ammonia refrigeration. Both absorption and compression systems are employed. In the latter case, the ammonia gas is compressed by the two Ingersoll-Rand Type XVG gas-engine-driven machines shown below. Both are 225-hp., 6-cylinder gas engines direct connected to three compressing cylinders. At the left is a Type 30, two-stage, air-cooled unit that is used for starting the larger compressors.



PUMPS IN "DOCTOR" PLANT

The gasoline resulting from the primary distillation of crude oil contains small amounts of hydrogen sulphide and mercaptans of sulphur and requires treatment before it is approved for blending with other gasolines to make a marketable product. The hydrogen sulphide is removed by washing with caustic soda, and the mercaptans are converted into unobjectionable compounds by means of a so-called "doctor solution" of lead oxide in caustic soda. The treatment takes place in tanks into which the various liquids, as well as water for a final washing of the gasoline, are pumped by the units shown here. All are Ingersoll-Rand Motorpumps.

engine power ends. A feature of these units is that they operate in two stages without intercooling between stages. The ammonia gas enters the machines at a pressure of 10 pounds, absolute, and at a temperature ranging from -25° to -41°F. It is discharged at a pressure of 175 pounds, gauge, and at a temperature of 275°.

There are three Goslin-Birmingham vacuum-type dewaxing filters, and a fourth is now being put in service. They are horizontal iron cylinders in which are rotary, cloth-covered drums each 10 feet in diameter and 12 feet long and having 375 square feet of filter area. The new unit, which is of the same diameter but 16 feet in length, provides 500 square feet of surface. They are driven at a speed of from 2 to 12 rpm., depending on the characteristics of the wax-oil-solvent handled. The filters are equipped with hoods which are solvent tight to prevent the escape of that highly volatile fluid. A vacuum is pulled on the interior of the drums, being low at the bottom and increasing toward the top to a maximum of 27 inches of mercury. The oil passes through the filter, while the wax collects in a cake on the outside. The latter is sprayed with solvent to wash out contained oil and is scraped from the drum and removed from the outer casing by a worm conveyor. The filters are served by an Ingersoll-Rand Type XPV-1 steam-driven, duplex, dry vacuum pump with 9x16-inch steam cylinders and 31x16-inch vacuum cylinders.

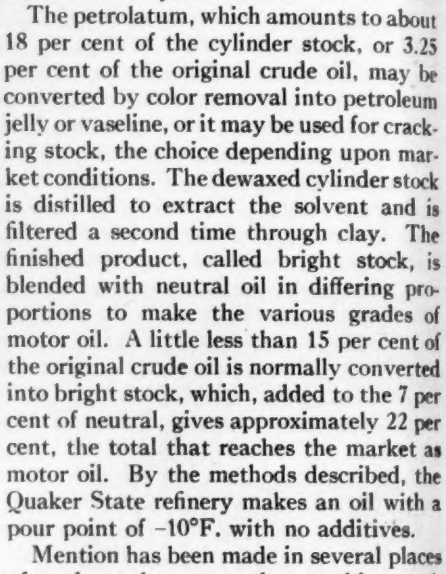
The wax extracted from the distillate is paraffin. As it comes from the filters it is known as slack wax and still retains a considerable amount of oil. This is removed by a process called sweating. The wax is melted and run into shallow pans that have pipes extending through them. Cold water passes through the latter, and when it has solidified the wax it is gradually warmed. This softens the wax without melting it and allows the oil to drain from it. The extracted oil is called foots-oil and is used for cracking stock: the wax is yellow and is filtered through clay to produce the familiar paraffin. It is of a superior grade and is given varying melting points up to 135°F. Much of it is sold to the paper-making industry.

The dewaxed oil-solvent solution from the filters goes to a solvent-recovery plant. The solvent is driven off by distillation and is used over and over, the loss each time it makes the cycle being very small. The oil is known as neutral oil, and has all the physical specifications of the finished product except color. It is filtered through clay to give it the desired color and then run to storage to be blended into motor oil. In its refined state it represents about 7 per cent of the original crude oil.

The remaining product of primary distillation is cylinder stock. It is diluted with naphtha to reduce its viscosity and filtered through a clay bed to remove coloring matter and carbon-forming constituents. After being filtered, it is red in color instead of green, as it was originally, and contains considerable quantities of petrolatum wax, which is an amorphous compound in contrast to the crystalline structure of the paraffin contained in the wax distillate. The petrolatum is extracted in the same manner as the paraffin and in the same filters, which are alternately used for wax distillate and cylinder stock.

The petrolatum, which amounts to about 18 per cent of the cylinder stock, or 3.25 per cent of the original crude oil, may be converted by color removal into petroleum jelly or vaseline, or it may be used for cracking stock, the choice depending upon market conditions. The dewaxed cylinder stock is distilled to extract the solvent and is filtered a second time through clay. The finished product, called bright stock, is blended with neutral oil in differing proportions to make the various grades of motor oil. A little less than 15 per cent of the original crude oil is normally converted into bright stock, which, added to the 7 per cent of neutral, gives approximately 22 per cent, the total that reaches the market as motor oil. By the methods described, the Quaker State refinery makes an oil with a pour point of -10°F. with no additives.

Mention has been made in several places of products that are used as cracking stock in manufacturing gasoline. The cracking process consists essentially in breaking up large molecules of hydrocarbons into smaller ones with lower boiling points by means of heat and pressure. A substantial



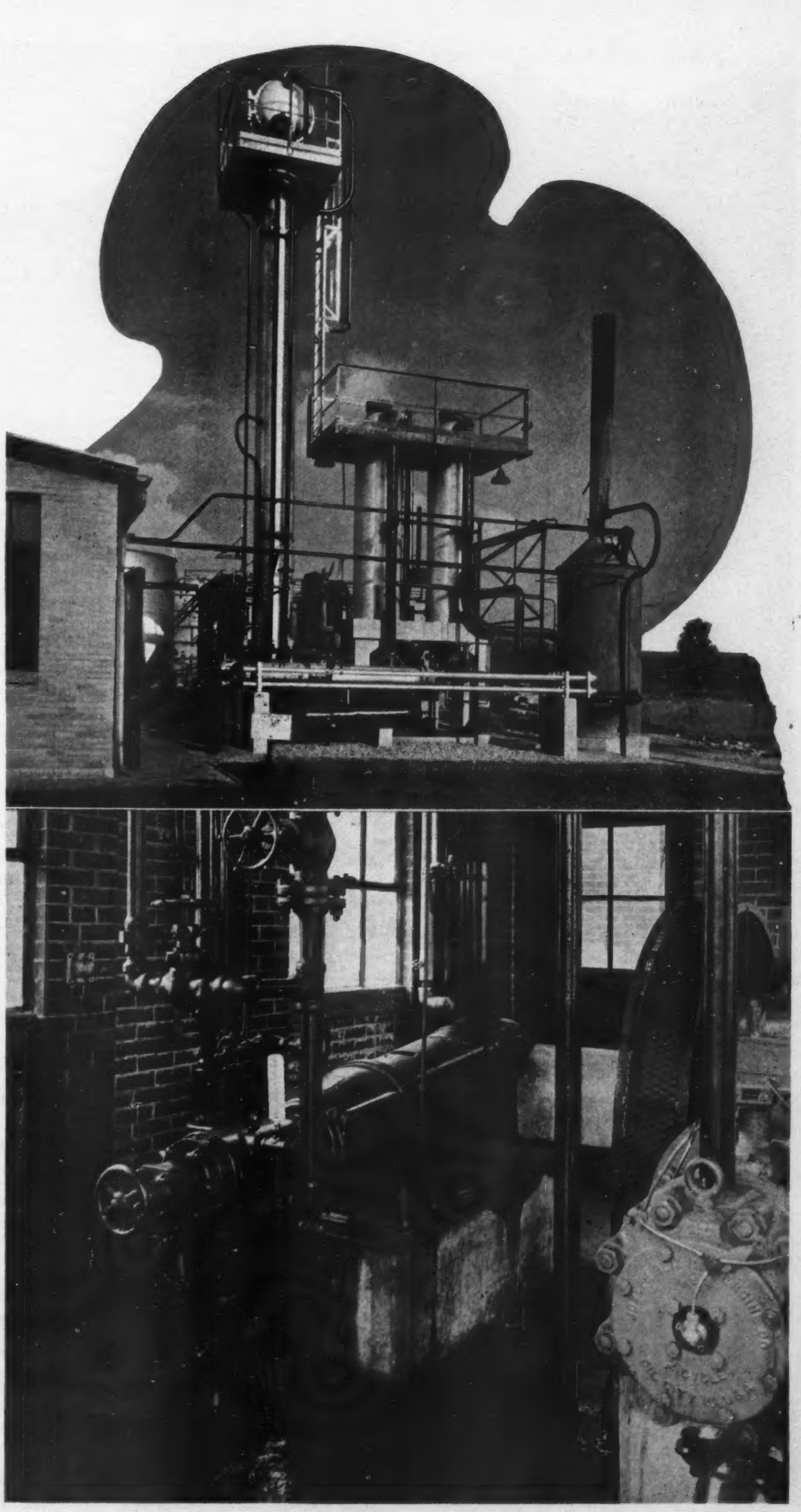
REFLUX ACCUMULATOR

From this unit, reflux is introduced into the top of the fractionating column of the Dubbs cracking plant to control the temperature there. The small Motorpump beneath the vessel serves when the equipment is being used to re-form naphtha and straight-run gasoline, for which purpose only small amounts of reflux are required in the fractionating column. When regular charging stock is being cracked, the reflux is handled by a steam-driven pump of larger capacity.

proportion of them comes within the composition range of gasoline. A Dubbs cracking unit, licensed by the Universal Oil Products Company of Chicago, is used for the purpose at the Quaker State plant.

The cracking stock is preheated by passing it through a fractionating column where it serves as a condensing medium for hot gases, and also by running it through heat exchangers. The hot oil is then pumped to a furnace where it is further heated by gas burners. It leaves the furnace at a temperature of 960°F. and under a pressure of 480 pounds. From there it goes first to a reaction chamber and next to a flash chamber where segregation into vapors and liquid residuum takes place at reduced pressure. The hot vapors pass through a heat exchanger where they heat incoming charging stock, and then they enter a fractionating tower where they are separated into gasoline, light oil, and reflux condensate. The reflux is pumped back into the fractionator to condense the heavier vapors rising through it. The gasoline vapors pass from the top of the tower to a water-cooled condenser where they are liquefied, the gasoline going to a distillate receiver from which it is passed through a stabilizer. The final product is run into storage tanks.

A certain amount of incondensable gas is discharged from the top of the distillate receiver and also from the stabilizer. Formerly such gas had to be either utilized for fuel or wasted; but now, thanks to the process of polymerization, it is possible to obtain gasoline from it. A Universal Oil Products Company polymerization unit was installed for this purpose at the McKean refinery last year. Through the phenomenon of polymerization is effected just the reverse of that accomplished by the cracking process. Instead of breaking up large hydrocarbon molecules into smaller ones, it builds up small ones into larger ones, most of which can be stabilized and liquefied to yield gasoline. The reaction takes place in towers in the presence of a phosphoric-acid catalyst that can be regenerated readily whenever that is necessary. The gas is introduced at a pressure of 500 pounds and at a temperature of 370°F. It is compressed by an Ingersoll-Rand Class ES-1 machine that is driven by a direct-connected, 25-hp. Reid gas engine. After passing through the catalyst tower, the gas goes to a condenser and then to a stabilizer. It is stabilized to a vapor pressure of 34 pounds. Approximately 600,000 cubic feet of gas is processed daily, and upwards of 90 per cent of it is being converted. This polymer gasoline is used to blend the straight-run gasoline and that from the cracking unit. The ultimate product has a vapor pressure of 9 pounds in summer and around 10 or 10½ pounds in winter. Polymer gasoline has a high octane number and materially increases the octane rating of the final, blended product. As a result, Quaker State is able to turn out a premium grade of gasoline that is marketed in a limited area.



POLYMERIZATION UNIT

The very volatile gases that formerly could be used only for fuel are largely transformed in the units shown at the top into stable hydrocarbons within the composition range of gasoline. Gasoline made in this manner is particularly valuable for blending with straight-run and cracking gasoline to improve its antiknock qualities. The reaction, which takes place in the presence of a catalyst, consists in combining small hydrocarbon molecules to form larger ones. Before entering the system, the gases are compressed to 500 pounds pressure by the machine in the picture immediately above. It is an Ingersoll-Rand single-stage unit with a capacity of 344,000 cubic feet per day. A part of the 25-hp. gas engine that drives it is seen at the right.

COOKE CITY

Rich float ore was found in this area in 1870, but Indians forced the prospectors to leave. Six years later there was a rush of gold seekers, and in 1883 Cooke City boasted 135 log cabins, two general stores, and thirteen saloons. The lack of a railroad hindered development of the ore deposits; but the highway alongside which this marker stands provides transportation facilities that promise to give Cooke City new life.

Montana's Unique Historical Road Markers

THE Montana Highway Department has erected throughout the state more than 100 roadside markers for the benefit of travelers. These markers are distinctive both in their design and in the phraseology of their inscriptions. Each marker consists of a framed 4x6-foot panel suspended from a crossbeam that is supported at the ends by posts set in a masonry base made up of field stone. Some of the cross pieces and posts are rough-sawed lumber and some are logs, either of which blends well with the natural surroundings. The cross pieces have been embellished with well-executed silhouettes that relate to the text on the suspended panel. Some of these silhouettes are painted and others have been given the appearance of weathered hand-carving by sand-blasting the background so that the design is in relief. Each marker is placed parallel to the highway on an especially constructed turnout that permits cars to park without creating a traffic hazard; and 1,000 feet from it, in both directions, are triangular-shaped pilot signs informing the traveler that he is approaching a historic point.

The individual marker bears several paragraphs giving facts about the location and some of its past history. The language in many instances is informal, with humor and western vernacular interspersed with more serious information. Any motorist that tours the state and stops to read all the markers will accumulate a goodly fund of knowledge of Montana's past and a wealth of sidelights upon the sort of people that developed it. The text material was assembled and written by Robert H. Fletcher, plans and traffic engineer of the Montana Highway Department, and reveals the author's thorough familiarity with Montana's history. The lettering is large enough to be read from parked cars several feet away, in which respect it differs from the legends on the bronze historical markers found in many eastern states.

Typical of the western flavor that characterizes the inscriptions is the following wording that appears on a marker at Havre:

Cowpunchers, miners, and soldiers are tolerably virile persons as a rule. When they went to town in the frontier days seeking surcease from vocational cares and solace in the cup that cheers it was just as well for the urbanites to either brace themselves or take to cover. The citizens of any town willing and able to be host city for a combination of the above diamonds in the rough had to be quick on the draw and used to inhaling powder smoke.

Havre came into existence as a division point when the Great Northern Railroad was built and purveyed pastime to cowboys, doughboys and miners on the side. It is hard to believe now, but as a frontier camp she was wild and hard to curry.

A marker between Butte and Silver Bow Junction gives the following information regarding Montana's great copper-producing center that is known the world over:

The "greatest mining camp on earth" built on "the richest hill in the world." That hill, which has produced over two billion dollars worth of gold, silver, copper and zinc, is literally honeycombed with drifts, winzes and stopes that extend beneath the city. There are over 3,000 miles of workings, and shafts reach a depth of 4,000 feet.

This immediate country was opened as a placer district in 1864. Later Butte became a quartz mining camp and successively opened silver, copper and zinc deposits.

Butte has a most cosmopolitan population derived from the four corners of the world. She was a bold, unashamed, rootin', tootin' hell-roarin' camp in days gone by and still drinks her liquor straight.

A former prominent mining area, Nevada City, now little more than a memory, is made to live again through the following vivid description:

A ghost town now but once one of the hell roarin' mining camps that lined Alder Gulch in the '60s. It was a trading point where gold dust and nuggets were the medium of exchange; where men were men and women were scarce. A stack of whites cost twenty, the sky was the limit, and everyone went heeled.

The first vigilante execution took place here when George Ives, notorious road agent, was convicted of murder and hanged.

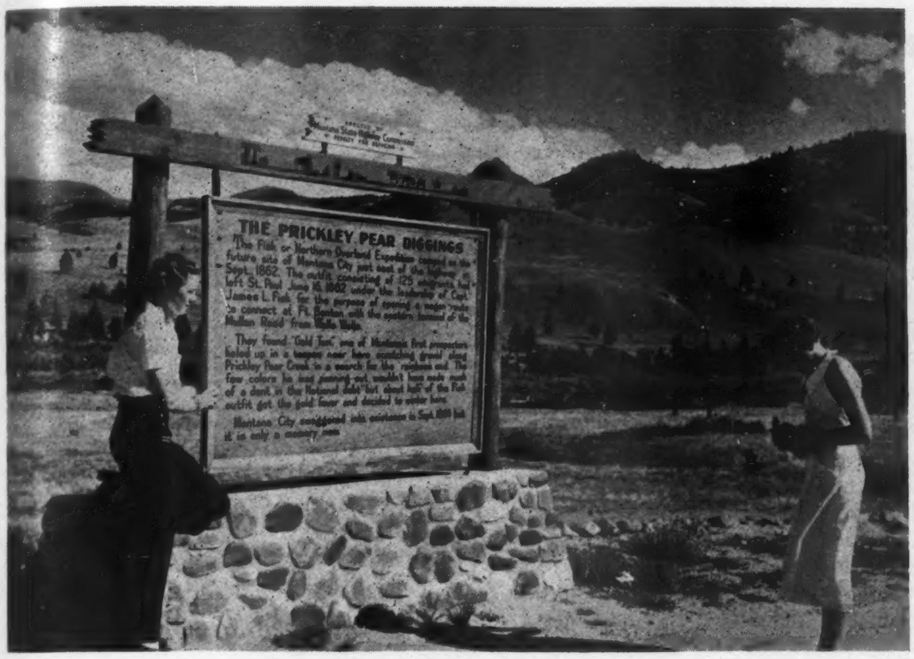
The gulch was once filled with romance, glamour, melodrama, comedy and tragedy. It's plumb peaceful now.

Just west of Roundup, in the midst of a section in which cattle raising was once the dominant industry, the picturesque language of the cowhand is used to give the reader an impression of former days there:

In the '80s—days of the open range—many a roundup outfit worked this country. The spring roundup gathered the cattle in order to brand and tally the calf crop. The fall roundup gathered beef critters for shipping.

An outfit consisted of the captain, the riders, the "reps" from neighboring ranges, the cavvy or horse herd in charge of the day herder and night hawk, the four-horse chuck wagon piloted by the cook, the bed wagon driven by his flunkey. Camp moved each day.

The cowboys rode circle in the morning,



THE PRICKLEY PEAR DIGGINGS

This marker is near Montana City just south of Helena at a spot where 125 emigrants from St. Paul, Minn., camped in September, 1862. There they found "Gold Tom," one of Montana's first prospectors, panning the gravels of Prickley Pear Creek for gold. Many of the travelers decided to stay there and try their luck. Nobody got rich; but their presence attracted others, and Montana City was established in 1864. It is only a memory now.

combing the breaks and coulees for cattle and heading them toward the central point to form a herd. In the afternoons of spring roundup the guards kept the herd together, the cutters split out the cows with calves, the ropers dabbed their loops on the calves, took a couple of dally welts around the saddle horn and dragged 'em to the fire. There the calf wrestlers flanked and flopped them and the brander decorated them with ear notches, or dew laps, and a hot iron. It wasn't all sunshine and roses.

Near Novary, a marker explains in interesting fashion why a military fort was established there 60 years ago:

Old Fort Maginnis, a military post built in 1880, was about eight miles north of here. This country was great buffalo range before that time but cattlemen were bringing in stock from the western valleys and Texas longhorns were being trailed in from the southeast. There wasn't room for both cattle and buffalo so the latter had to go. This put a crimp in the Indians' eating arrangements. The soldiers were supposed to ride herd on the roving, redskin brothers to keep them from mistaking cattle for buffalo.

There were also quite a number of pale-face parties who were handy with a running iron and prone to make errors as to brands and ownership. Such careless souls were known as "rustlers." Sometimes the cattlemen called on these pariahs with a posse and intimated that they were unpopular. Usually such a visitation cured a rustler or two permanently.

The Lewis and Clark Expedition and the exploits of Jim Bridger are mentioned on numerous markers. The following character sketch of Bridger appears near the town that is named for him:

Jim Bridger arrived in Montana in 1822 as a member of a Rocky Mountain Fur Co. brigade. For years he had no more permanent home than a poker chip. He roamed the entire Rocky Mountain region and often came through this part of the country. A keen observer, a natural geographer and with years of experience amongst the Indians, he became invaluable as a guide and scout for wagon trains and Federal troops following the opening of the Oregon Trail.

He shares honors with John Colter for first discoveries in the Yellowstone Park country. He was prone to elaborate a trifle for the benefit of pilgrims, and it was Jim who embroidered his story of the petrified forest by asserting that he had seen "a peetrified bird sitting in a peetrified tree singing a peetrified song."

Early day desperadoes also are singled out for attention on some of the signs. Between Wagner and Malta there is a marker that reads:

Take it by and large, the old West produced some tolerably lurid gun toters. Their hole card was a single-action frontier model 45 Colts and their long suit was fanning it a split second quicker than similarly inclined gents. This talent sometimes postponed their obsequies quite a while, providing they weren't pushed into taking up rope spinning from the loop end of a lariat by a wearied public. Through choice or force of circumstances these parties sometimes threw in with the "wild bunch"—rough riding, fast shooting hombres prone to disregard the customary respect accorded other peoples brands.

Kid Curry's stomping ground in the '80s was the Little Rockies country about forty miles southwest of here. July 3rd, 1901, he pulled off a premature Independence Day celebration by holding up the Great Northern No. 3 passenger train and blowing the express car safe near this point. His departure was plumb hasty. The Great Northern would still probably like to know where he is holed up.

Tribute is paid to the great Indian warrior Chief Joseph; and for the treatment that was accorded him, the white race is indicted in the following words that make up a marker at Chinook commemorating the Battle of the Bear's Paw:

This battle was fought in October, 1877, on Snake Creek about 20 miles south of here near the Bear Paw Mts. where after a 3 day's siege Chief Joseph, leader of the Nez Perce Indians, surrendered to Col. Nelson A. Miles of the U. S. Army.

The usual forked tongue methods of the whites which had deprived these Indians of their hereditary lands caused Joseph to lead his people on a tortuous 2,000 mile march from their home in Idaho to evade U. S. troops and gain sanctuary in Canada.

This greatest of Indian generals fought against fearful odds. He and his warriors could have escaped by abandoning their women, children and wounded. They refused to do this.

His courage and fairness were admired by Col. Miles who promised him safe return to Idaho. One of the blackest records in our dealings with the Indians was the Government's repudiation of this promise and the subsequent treatment accorded Joseph and his followers.

MEADERVILLE

Near this spot in the Butte area, William Allison and G. A. Humfreys located a mining claim in 1864, having discovered an abandoned prospect hole that had been dug some years before. Around it were found pieces of elk horn that had evidently been used as drills. Allison and Humfreys failed to find the riches that lay beneath the surface and died without knowing that they might have become millionaires.

Steam Condensers

PART 1

A. D. Kann

A CONDENSER reduces a vapor to its liquid state by the removal of the latent heat of vaporization, usually at substantially constant pressure. In a steam condenser the resultant liquid is water. The operating pressure may be above atmospheric, atmospheric, or subatmospheric (vacuum). In general, steam condensers are used to reduce to water, at a pressure below atmospheric, exhaust steam issuing from some device in which it has performed mechanical work. Because a low condensing pressure (high vacuum) usually enables the user to obtain more work out of the steam before it is condensed, the performance of a condenser is evaluated largely by the absolute value of the low pressure (high vacuum) which it will maintain under specified conditions of load (steam flow), circulating-water temperature, and quantity of circulating water. The reduction of the entering steam to water is usually a secondary objective even though it is important, valuable, and unavoidable.

Cooling Medium

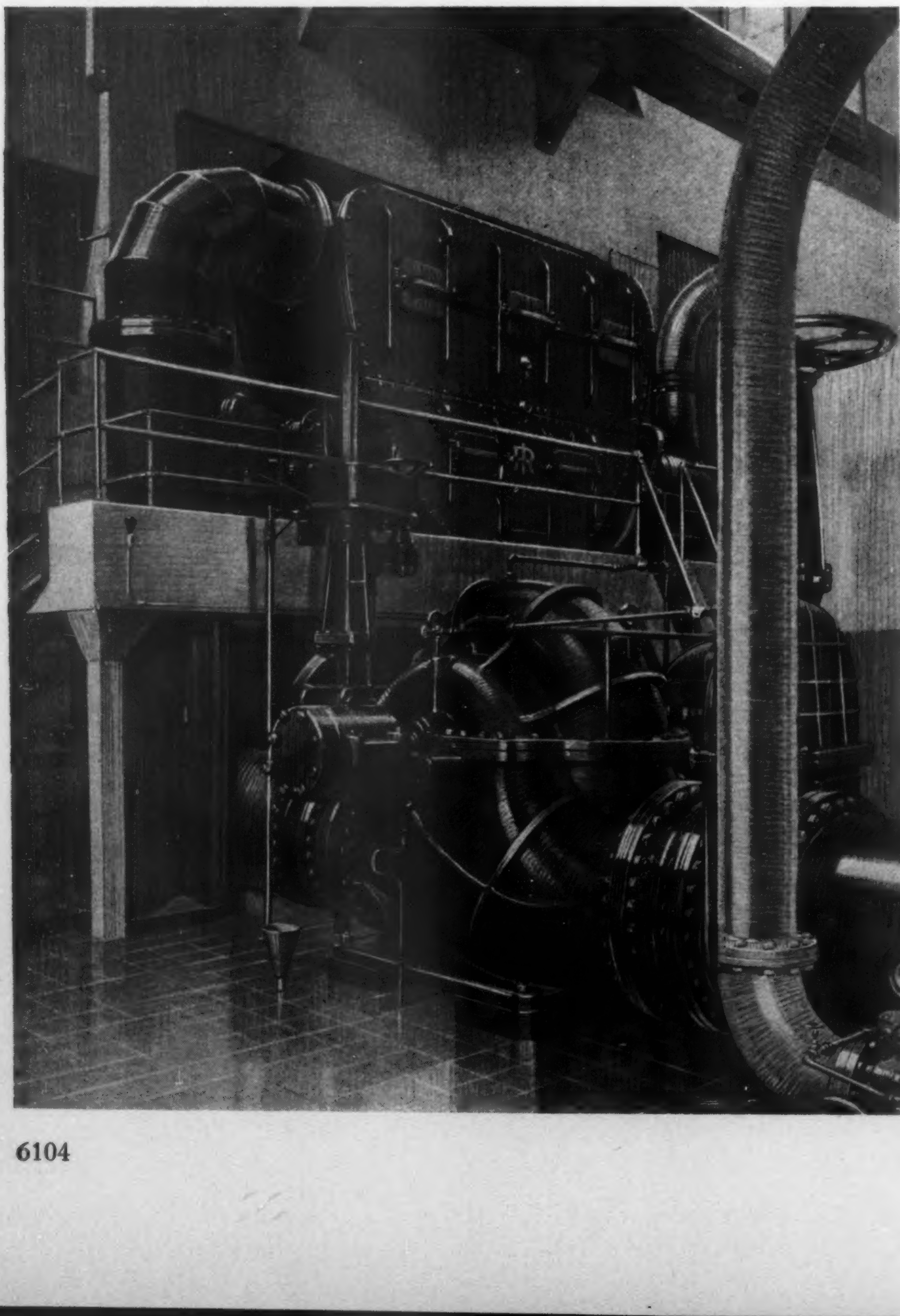
As a steam condenser operates by removing heat from the entering steam, it must necessarily discharge this heat somewhere if it is to continue in operation. Therefore, a heat-removal medium or cooling fluid is required. The cooling medium may be almost any available liquid or gas. Air is sometimes used, and occasionally crude oil; but in the majority of applications water is circulated to take away the heat liberated by the condensing steam.

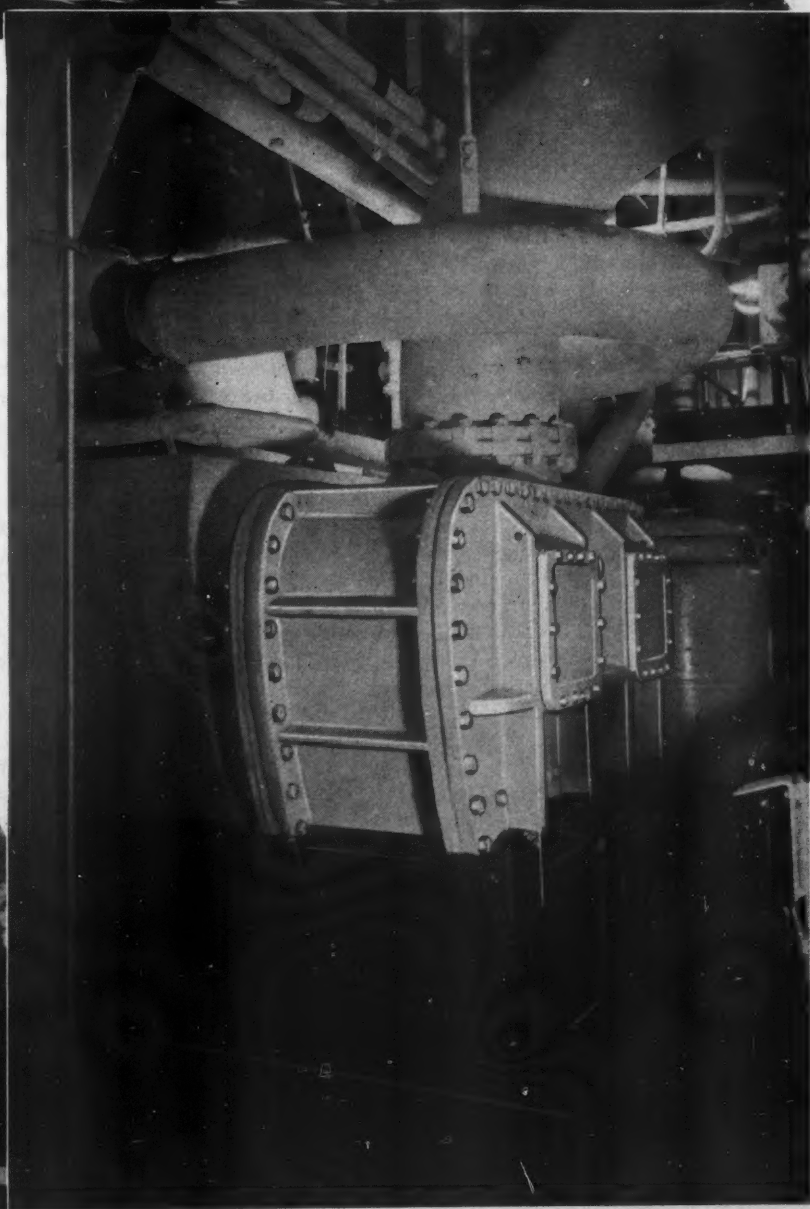
Condenser Vs. Heater

Obviously, the cooling medium is heated in the process, and it is apparent that every steam condenser is also a heater, generally a water heater. If we will think of a condenser as a water heater, it should assist us materially in getting a clear understanding of the important relationships that are involved in condenser operation, selection, and design.

Elementary Condenser

Supposing a condenser to be a steam-heated water heater, the simplest form that can be visualized is a pail of cold water with a steam hose immersed in it. To heat water, we would open the steam valve and let some steam blow into the water. As the water in the pail is subject to atmospheric pressure, the pressure in the steam line would have to be higher, say 10 pounds gauge. It will then blow freely into the





A GRACE LINER

Space is at a premium aboard ships, and high efficiency per square foot of surface is therefore an important consideration in the selection of condensers. At the same time, dependability is a vital requirement. Above is shown one of the Grace Line "Santa" ships with turbo-electric drive, and at the right is one of the two Ingersoll-Rand main condensers that serve her 6,700-hp. main propulsion turbine.

CENTRAL-STATION SERVICE

Improvement in condenser design and performance has paralleled the development of more efficient and larger steam turbines and has contributed notably to the over-all low cost of generating electric power both in central stations and industrial plants. At the extreme left is an Ingersoll-Rand surface condenser with 31,600 square feet of cooling surface. It serves a 55,000-kw. turbine-generator in the Gilbert Station of the New Jersey Power & Light Company. In the foreground is the centrifugal pump that handles the circulating cooling water through the condenser. At the left is a view of the Gilbert Station.

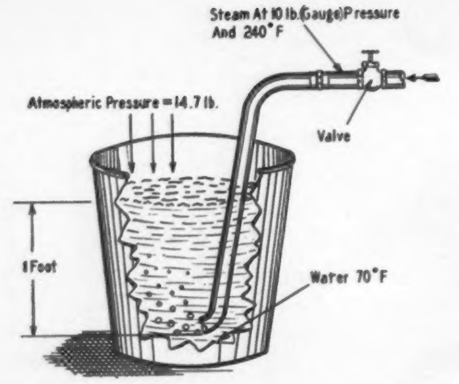


Figure 1

water. Many of us have seen this done and have heard the racket and commotion that occurs at first. It is very easy to heat water in this way. As the steam issues from the hose it quickly condenses in the water, leaving a more or less perfect vacuum where an instant before there had been a bubble of steam. The atmospheric pressure on top of the water, plus the absence of any material pressure within the condensed bubble, cause the latter to collapse with a bang. This simple experiment illustrates that the process of condensation (and heat transfer) really is instantaneous.

Temperature Difference

This pail-and-steam-hose heater has some of the fundamental design factors of a typical steam condenser. Let us see what they are. At the start of operations we have a steam pressure (at the outlet of the hose) of 1 atmosphere, plus the static head of the water, say 1 foot, on the open end of the hose. (The shut-off valve in the steam line controls the flow by throttling, but it does not of itself determine the pressure in the open-ended hose.) If we take 1 foot of water to be equal to 0.4 lb./sq. in., the condensing pressure in a steam bubble will be $14.7 + 0.4 = 15.1$ pounds per square inch (absolute) and the saturated steam temperature will be about 213°F. With water at 70°, we have a temperature difference, *TD*, of $213 - 70 = 143°$ to cause heat to flow from the steam to the water. Remember this *TD*. It is perhaps the most vital factor in the design, selection, or utilization of any condenser. Without a *TD* there would be no condensation and no heating of the cooling water.

The instant after the bubble had formed it vanished. The steam in the bubble had liquefied and been mixed with the surrounding water. But if it had been practicable to get a slow-motion movie of the bubble at that instant, it would have been observed that it was decreasing in size at a very high but measureable rate; and if the steam pressure in the bubble had been measured during the collapse, it would necessarily have been constant (15.1 lb./sq. in.).

Heating Effect

Suppose we assign a value to the quantity of steam in the bubble at the start. If the bubble is 2½ inches in diameter it will have a volume of 0.0047 cubic foot and contain 0.000178 pound of steam, according to the steam tables (specific volume 26.3 cu. ft./lb. at 15.1 lb./sq. in. absolute). The steam tables also show that the latent heat of saturated steam at 15.1 lb./sq. in. absolute is about 970 Btu. per pound, so our bubble will release 970 x 0.000178 or 0.17 Btu. in collapsing to 213° water, which mixes with the cold water in the pail and gives up a little more heat in being cooled to a point below 213° as water. Disregarding this item (about 15 per cent in this case, ordinarily very small) and assuming that there are 2 gallons (16.7 pounds) of water in the pail, we can calculate the degree of heating accomplished by the one 2½-inch bubble of steam. As it takes 1 Btu. to heat 1 pound of water 1°F. (approximately) and we have 0.17 Btu. released in the water, the average temperature in the pail will rise

$$\frac{0.17}{16.7} = 0.01° \textit{ to } 70.01°\text{F} \quad \textit{(approximate)}$$

The following bubble will heat the water to 70.02°, and so on in very rapid succession as the bubbles form and break away from the hose end. The turbulence will be violent if there is an appreciable flow of steam. But, within the limit of blowing the water out of the pail, or steam breaking through the surface of the water, the initial capacity of the pail as a condenser is automatically adjusted with the flow of steam. That is, the capacity is not determined particularly by the size of the pail nor by the quantity of water in it. Consequently, as a water heater, the initial rate of raising the temperature of the water is rapid or slow according to the steam flow. All the heat in the steam enters the water with the steam so long as all the steam is condensed. All the steam will be condensed so long as an adequate temperature difference (*TD*) exists.

Transfer Surface

This brings us to another concept, that of surface and rate of heat transfer per unit of surface. As the heating of the water proceeds, the temperature of the water in the pail will rise from 70° to 90°F., and so on. Meanwhile, the pressure on the steam bubbles being constant, the temperature difference between them and the water drops from 143° to 123°, to 113°, and finally to a point where the steam flow will have to be cut down to avoid blowing some of the steam through the water. When this point is reached, it is obvious that the action of our water heater has been slowed down and the capacity of our condenser (in terms of steam flow—that is, pounds per hour) has been reduced all because the *TD* (difference between steam and water temperature) has been lowered.

If we assume that all the steam bubbles are of uniform size—2½ inches in diameter, each will have an inclosing water surface of 0.136 square foot. The water film actually in contact with the steam will have steam temperature (213°) by virtue of that contact. This water film forms the actual condensing surface. The water immediately outside of this film is cold and moving and it conducts heat rapidly from the 213° film by convection. Convection means the bodily movement of heated particles interchanging their position with less heated particles. Convection takes time. Although it takes time it can be very rapid, and, other factors remaining constant, it has been found to be directly proportional to temperature difference. In direct-contact interchange the exact rate of transfer cannot be readily measured because it is virtually impossible to measure the area of the surface through which the transfer occurs. Nevertheless, we can assume a figure and see how it affects the performance of the simple steam-hose-and-pail water heater. (We shall disregard the changing ratio of surface to volume of the bubble as it decreases in size. The smaller a sphere becomes, the greater the ratio of surface to volume, and the more rapidly the remaining steam is condensed. This accounts for the sudden collapse of each bubble, and indicates why better action is obtained when the steam flow is introduced through a large number of small perforations than through an open hose.)

It is probable that the actual rate of condensation in a direct-contact steam condenser or water heater is on the order of 3,000 Btu. per hour per square foot per degree of Fahrenheit temperature difference. This means that 3,000 Btu. can be transferred through one square foot of water-steam surface for each degree of temperature difference between the steam and the water. Referring to our 2½-inch bubble with 0.136 square foot of surface and 0.17 Btu. to be transferred, the time to effect this transfer —provided the bubble did not change in diameter as the process proceeds—would be as follows:

$$\textit{Btu.} = \textit{Rate} \times \textit{Time} \times \textit{Area} \times \textit{TD} \qquad (1)$$

$$\textit{or Time} = \frac{\textit{Btu.}}{\textit{Rate} \times \textit{Area} \times \textit{TD}} = \textit{Hours}$$

$$\textit{or Seconds} = \frac{\textit{Btu.} \times 3600}{\textit{Rate} \times \textit{Area} \times \textit{TD}}$$

$$= \frac{0.17 \times 3600}{3000 \times 0.136 \times 143}$$

$$= \frac{612}{58400} = 0.0105$$

or about 1/100 *of a second.*

After running the steam into the pail of water until the water is heated to 141°F., the available *TD* has been reduced to 72° and, according to the equation, the time required for one bubble to condense has been doubled to 0.02 second. This is still a short time; but it is also evident that if,

at the time of starting, we had run just as much steam into the water as could be handled without breaking through the surface, we would now run in only one-half as much. This means that with the TD cut in half, the capacity in steam flow is cut in half, or the water heater is slowed down to half speed.

Again, when the water temperature has risen to 177°F., the TD will be only 36°; the time for condensing one of our bubbles will be increased to 0.04 second; the steam-condensing capacity will be cut to one-quarter; and the water-heating rate will have been slowed down to quarter speed. Finally, if the pail of water is heated to 213° (212° on the surface), the TD will be zero; any steam bubbles introduced will not condense, they will float to the surface; and we can heat the water no further. Thus it is apparent that the elementary heater will be useful only temporarily—it is only a "batch" heater.

Continuous Heating

The equipment has stalled because it was not designed for continuous operation and because there was no way of increasing the pressure on the steam bubbles and, consequently, the steam temperature to maintain a useful TD. It is evident that the hose-and-pail water heater can readily be made continuous if a supply of cool water under sufficient head is run into and out of the pail, like this:

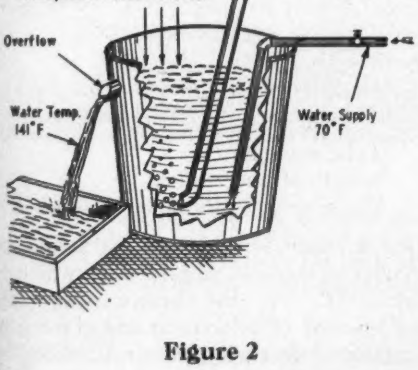


Figure 2

Referring to Figure 2, it will be seen that we now have two points of control: steam flow and water flow. If the steam flow is at a fixed rate, say 100 pounds per hour, we can regulate the cool-water supply so that the quantity, or rate of flow, will give us the desired overflow- or heated-water temperature. Let us assume that 141°F. overflow temperature is wanted. As the water in the pail will be very turbulent, we can assume, for the sake of simplicity, that it is all at 141° and that the cool water is raised to this figure as fast as it enters.

Terminal Temperature Difference

It seems that there are now two temperature differences. The initial TD between the steam (213°) and the incoming water (70°) is 143°F. as before, and the final TD between the steam (213°) and the outgoing water (141°) is 72°. In this case, on the supposition that only 141° water is in contact with the steam bubbles, the TD that effects heat transfer from the steam to the water is the final TD. Therefore, the rate at which steam can be condensed is limited by the final TD of 72°.

Temperature Rise

The heating of the flowing water from 70° to 141°F. is called the temperature rise of the water, or TR. This figure is always a direct function of the quantity of steam condensed per unit of time and the quantity of water flowing per unit of time. It is a simple interchange, and the balance cannot be affected by any other factors. All the available heat in the steam condensed must be absorbed by the water doing the condensing and being heated by it.

Thus: $TR \times GPM \times 500 = Lb./Hr. \times Btu./Lb.$

$$\text{or } TR = \frac{Lb./Hr. \times Btu./Lb.}{GPM \times 500} \tag{2}$$

$$\text{or } GPM = \frac{Lb./Hr. \times Btu./Lb.}{TR \times 500} \tag{2a}$$

If our continuous open-pail water heater can condense 100 lb./hr. of steam with a latent heat of 970 Btu./lb. when the final TD is 72°F., and if the water is heated from 70° to 141° (a 71° TR), then, in order to obtain this balance, the GPM of water must be:

$$GPM = \frac{Lb./Hr. \times Btu./Lb.}{TR \times 500} \tag{2a}$$

$$\frac{100 \times 970}{71 \times 500} = 2.73$$

Approach

The final temperature difference mentioned in the foregoing is sometimes called "approach"—that is, it is the extent to which the temperature of the fluid being heated approaches the temperature of the fluid doing the heating (the steam temperature).

Ratio

Another relationship has developed, now that we have a continuous heater. It is represented by the ratio of temperature rise to the initial temperature difference, or

$$\frac{TR}{TD} = R = Ratio \tag{3}$$

This ratio represents the extent to which the water is actually heated as compared to the extent to which it might have been heated (or could have been heated theoretically) if the water, in infinitely slow passage through the pail, had been brought up to steam temperature. In other words, a ratio of 1.0 represents the unattainable ideal, which is never encountered in practice. Consequently, the value of R in any commercial design is always less than 1.0, and the actual value of R affords an important gauge of condenser design and performance, as will be developed later. In our present example, the value of

$$R = \frac{71}{143} = 0.50$$

which is a very ordinary ratio.

Having developed these new conceptions of "approach," temperature rise, and ratio, it immediately becomes apparent that the initial temperature difference is no longer the single important gauge of the performance of a water heater or condenser. The rate at which the cooling water is circulated continuously becomes a very vital factor. If the GPM is large, the TR is small and R is low, but the "approach" is large and the capacity is great. When the GPM is small, the TR is large and the ratio is high, but the capacity is relatively small. As TR cannot exceed TD, the relative capacity determined by R is made specific by the magnitude of TD. As always, without a TD of sufficient size, we cannot hope to get capacity, no matter how far we push up the GPM and reduce TR and R.

A crude condenser-heater, such as the water pail and steam hose, represents little in the way of design, and it has been necessary to oversimplify in order to make the relationships clear. Because water circulation in its case is chiefly attributable to turbulence, we cannot develop the transitory condition of the water as it flows through the apparatus nor arrive at certain accepted factors of surface-condenser design. Consequently, it would seem to be worth while to modify the pail and hose, to close it, so that we can get nearer to our objective.

The open pail can operate only at a fixed pressure, approximately atmospheric. Being open it has certain advantages. These are:

- *a*-Free release of any air in the steam.
- *b*-Absence of any metallic heat-transfer surface that offers resistance to the flow of heat and that requires cleaning or replacement.
- *c*-Low cost.

It also has disadvantages, among which are:

- *a*-Can be operated only at atmospheric pressure.
- *b*-Condensed steam is mixed with the water being heated and cannot be recovered as distilled boiler-feed water.
- *c*-Circulating water cannot be confined in a closed hydraulic circuit.

Surface-Type Heater

For these reasons, and other secondary advantages, closed-coil or shell-and-tube water heaters, as well as shell-and-tube (surface) condensers, have a wide field of application. Conversion of the continuous water heater shown in Figure 2 into a closed-coil heater (Figure 3) or a shell-and-tube heater (Figure 4) is readily visualized.

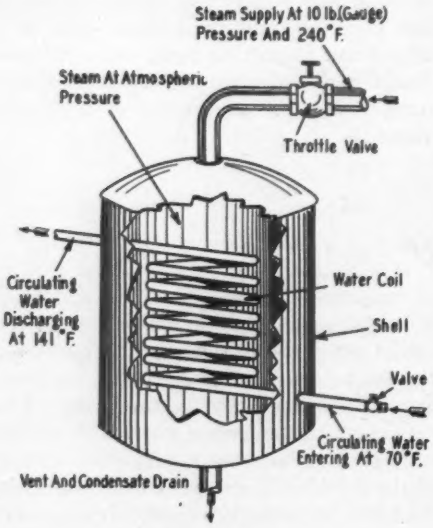


Figure 3

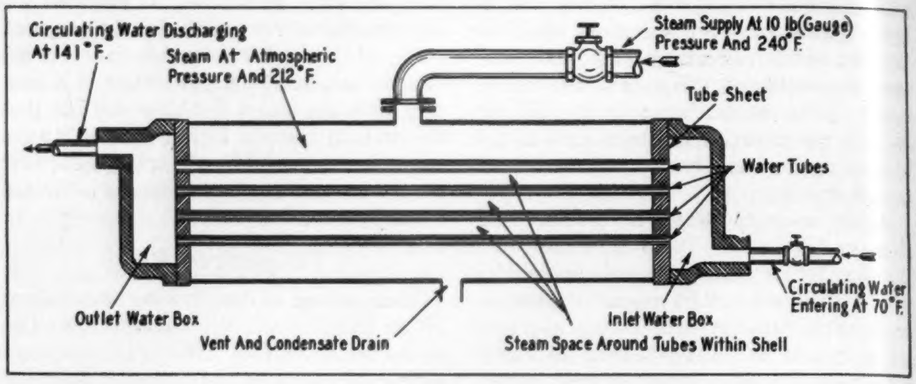


Figure 4

Although their construction is quite dissimilar, it is obvious that the two arrangements just illustrated are functionally similar. Many a water heater of the "old days" was built on the same lines as Figure 3. Possibly surface condensers for prime movers were once constructed that way. Although there is but one coil in Figure 3, and a single path for the water through the tube, it is entirely practicable to have several coils nested in the shell, with the water flowing in parallel through all of them, just as the shell-and-tube type has a multiple path for the water through the several tubes.

In Figures 3 and 4 we have shown the steam entering the shell and surrounding water-filled tubes; but we could obtain the same performance relationship with steam in the tubes and flowing water in the shell. In fact, water heaters and condensers have been built this way, particularly heaters using high-pressure steam which is confined more easily and safely in small tubes than in large shells. However, in vacuum condensers the steam volume is large, the pressure low, and it is possible to control the water velocity more effectually when the water flows through the tubes.

Effect of Fixed Surface

In considering Figures 3 and 4, we are confronted with the same elements that obtain in the case of Figure 2. Now, however, the heat-transfer surface separating the uncondensed steam and the flowing water is a fixed metal wall of specific area. No longer does the rate of steam flow determine the number or size of bubbles and the consequent area of transfer surface. In a way, this makes analysis simpler; but, at the same time, it introduces additional factors.

Resistance

Instead of a collapsible steam-to-water film that is infinitely thin and mobile and that permits a probable heat transfer of, say, 3,000 Btu./hr. per square foot, we have the fixed resistance of a metal-tube wall, plus the resistance of a condensate (water) film on the outside of the tubes, plus a stagnant-water film on the inside of the tube walls, all tending to oppose rapid heat flow and all setting up a temperature "gradient."

Of these, the metal wall generally offers the lowest resistance, especially when thin-wall brass or copper tubes are used. That of the condensate film also is very low; but the film of stagnant water clinging to the inside of the tubes sets up a very appreciable barrier to the rapid convection of heat from the tube metal to the moving stream of water passing through the tube. Fortunately, the effect of these resistances can be evaluated; and in the case of the waterside film it can be controlled. This is achieved by regulating the velocity of the water flow.

There is a fourth resistance of varying importance—dirt; and under ordinary conditions of operation or design, a fifth resistance of great importance—an air film. These parasitic resistances will be discussed later, for they must be considered and evaluated in condenser selection, although they should not be involved on the basis of condenser theory alone. These two forms of resistance, by the way, do not generally require attention in direct-contact (steam-to-water) condensers, an outstanding advantage of that type.

Velocity

Returning to the new factor—velocity, countless experiments and theoretical analyses have established a definite correlation between velocity and the rate of heat transfer through the stagnant film of water next to the inner wall of the tube through which the water is flowing. This law of heat transfer involves the effects of viscosity (affected by temperature), density, conductivity, rate of mass flow, etc. With water at ordinary temperatures as the cooling (or heating) medium, the law is reduced to a direct and semiproportional relationship. It amounts to saying that the rate of heat transfer through the stagnant film increases (or resistance decreases) as the linear velocity of the water in the tube increases. This increase in the heat-transfer rate roughly approximates a proportion equivalent to the square root of the velocity increase.

This effect can be crudely explained by assuming that the stagnant film varies in thickness, being "scraped" thin at high velocities and thickening at lower velocities. At any rate, by adopting a tubular type of construction, with the steam and water separated, we are able accurately to predict the rate of heat transfer and to plan with a specific set of performance conditions in mind. This, in turn, may be interpreted as saying that we can now design an assembly of shell and tubes which, with water at a suitable velocity, will provide us with almost any desired ratio of

$$\frac{TR}{TD} \text{ or } R \tag{3}$$

The important fact that should be remembered, if we are to have an adequate conception of surface condenser behavior, is that R depends entirely on structural proportions and water velocity. Small corrections have to be made for water temperature, but the inherent relationships are not disturbed.

The actual physical factors affecting the value of R may be listed as follows:

Tube diameter
Length of water travel
Water velocity through the tubes.

After a condenser has been built, velocity remains as the only variable with which to control R. As the heat-transfer rate is a function of velocity in any given construction or assembly, R is related to the heat-transfer rate. There is an advantage in thinking in terms of R, because this factor gives a much better idea of what the unit will do as a condenser (or heater) than does the heat-transfer rate. For example, two condensers with an identical R value might be selected or designed. One might have a lot of surface, cost a lot of money, and operate at a low heat-transfer rate. The other might have much less surface, cost much less, and operate at a high heat-transfer rate. If both use the same quantity of water they would handle the same steam load equally well and at the same condensing pressure (or vacuum). In other words, in R the effects of area and rate are combined in a single performance factor.

This article is in three installments. The second one will appear in the April issue.

Stationary Compressors Supply Air for Braking Trains

C. E. McManus*

ORE TRAIN AND COMPRESSOR

The right-hand picture shows an ore train at a loading ramp, with the air hose connected to the air line on the rear car. As the train moves down the grade by steps in spotting each car successively under the loading ramp, the air hose trails behind. The compressor, which is located in the small house at the right of the track, is seen at the left. It is a Type 40, two-stage, air-cooled machine driven by a 25-hp. motor. There is a compressor at each of the six loading stations.

ONE of the large open-pit iron mines on the Mesabi Range in Minnesota has worked out a system of braking railroad ore trains by which the cars are successively spotted under the loading pocket without the use of a locomotive to furnish the needful air. Instead, air is conducted into the regular train line from a stationary compressor housed near the loading station.

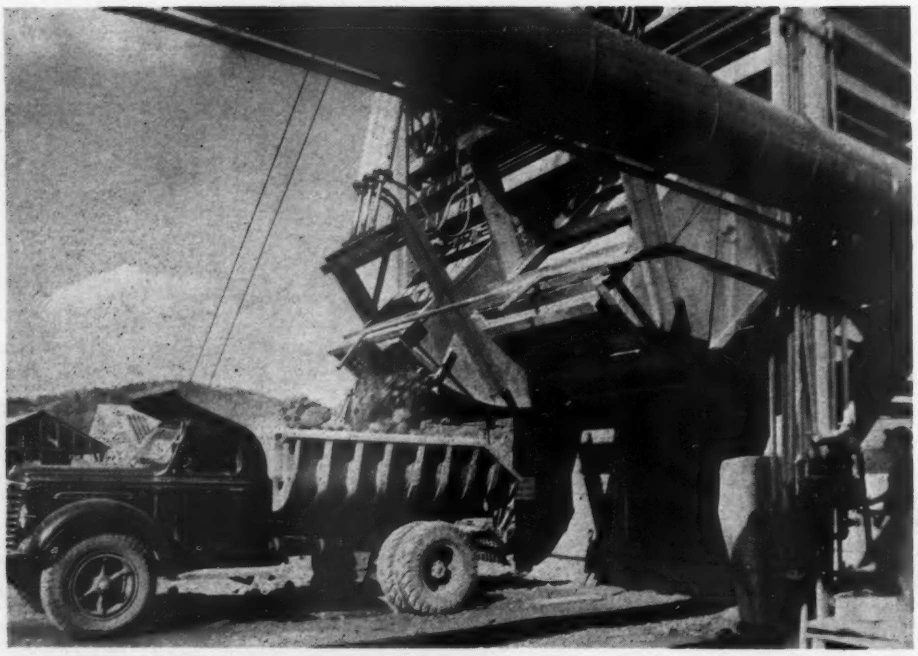
In the pit, the ore is loaded by power shovel into 15-ton diesel-engined trucks that haul it to a railroad spur at the pit side. There the trucks ascend a ramp and dump directly into 20-cubic-yard stripping cars. Eight of the latter make up a train and transport the ore to a concentrating plant. Efficient operation demands that the loading at the ramp be carried out with no delays, and this necessitates moving the cars quickly, one after the other, under the loading station. By means of the scheme adopted this can be done without the services of more than one locomotive.

The locomotive hauls a train of empties from the concentrator to the loading point and spots the forward car under the ramp. Then it picks up a loaded train and takes it to the concentrator. The empties are on a 1½ per cent grade, which permits them to be dropped by gravity, eight moves being required to spot each car, in turn, beneath the ramp.

Positive control of the train is effected by means of the regular Westinghouse air-brake system. A long hose is run from an air receiver to the rear car of the train and there hooked up to its air line—the hose trailing the train as it goes down the grade. Valves located at the top of the ramp enable the dumpman to control the spotting operation. When all the cars have been fully loaded, the trailing air hose is uncoupled and the train dropped to a passing track to await the return of the locomotive. The cycle of operations is timed so that the locomotive can make a round trip to the concentrator while a train is being loaded.

There are six of these loading stations, each served by an individual compressor. The units are automatically regulated to maintain a discharge pressure of between 80 and 90 pounds. Ordinarily, only one receiver is required, and it is located at the compressor. In a few cases, however, where the compressor is situated several hundred feet from the ramp, an additional receiver is installed at the ramp to insure an ample supply of air.

*Engineer, Butler Brothers.



SPRAYS IN SERVICE

As the muck comes from the hopper it is sprayed with disinfectant from a pipe directly overhead. Tests have determined that this method is more satisfactory than applying the solution to the entire load after it is in the truck.

Disinfecting Tunnel Muck

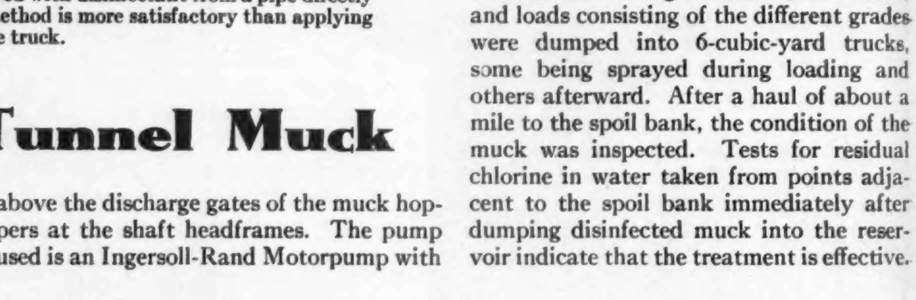
THE photograph and drawing reproduced on this page illustrate a method that is being used by the Frazier-Davis Construction Company, one of the contractors on the Delaware Aqueduct, to disinfect shaft and tunnel spoil before it is deposited on the banks of West Branch Reservoir from which New York City obtains part of its present water supply. The muck is being raised through dual shafts, and the designated disposal area is located directly on the reservoir shore. The specifications require that all excavated materials be disinfected before placing by spraying them with a solution of hypochlorite of lime, or by any other approved means. In compliance with this clause, the contractor has adopted the following procedure, which is described in *The Delaware Water Supply News* published by the Board of Water Supply of the City of New York.

A commercial bleaching powder, containing 35 per cent of available chlorine, is delivered in 330-pound metal drums and used to make a solution in the proportion of 24 pounds to 100 gallons of water. The mixing is done in a wood-stave tank with a capacity of 2,000 gallons. It is at one end of the shed in which the chemical is stored, and situated so that it is possible to roll the containers to the edge of the vat and to dump them without much handling. As a safeguard against the caustic action of the chlorine, the man that does the mixing wears rubber clothing and a gas mask. Stirring is done with a long wooden pole.

The solution is delivered from the tank through a 2-inch pipe to nozzles located above the discharge gates of the muck hoppers at the shaft headframes. The pump used is an Ingersoll-Rand Motorpump with all-iron fittings, a hard-steel shaft sleeve, and a special lubricator. It is driven by a splashproof, ball-bearing motor. An all-brass, acid-resistant meter is interposed in the line to measure the flow of the disinfectant in gallons. It has a face recorder similar to that on the familiar gasoline pump at service stations, and makes it easy to see the quantity being applied to each truckload of muck. For winter operations, the mixing tank has been housed in, the solution is being heated to about 70°F., and all exposed piping has been insulated.

The controls for the sprays, the meter, and the hopper gates are located close together and within convenient reach of the truck drivers. Each driver backs his vehicle under a chute and operates the controls himself. The solution is applied into the stream of the falling muck at the rate of 4 gallons for each cubic yard, as it has been determined by tests that this amount insures complete coverage of the rock and leaves a minimum of unabsorbed liquid in the bottom of the truck.

In making the tests, the rock was grouped in three sizes—large, medium, and small, and loads consisting of the different grades were dumped into 6-cubic-yard trucks, some being sprayed during loading and others afterward. After a haul of about a mile to the spoil bank, the condition of the muck was inspected. Tests for residual chlorine in water taken from points adjacent to the spoil bank immediately after dumping disinfected muck into the reservoir indicate that the treatment is effective.



LAYOUT OF SYSTEM

The intake of the pipe leading to the pump is about 6 inches above the bottom of the tank. This allows heavy sludge to accumulate on the bottom, from which it is drawn off at intervals through a drainage valve. By means of a by-pass from the pump to the top of the tank the solution is continually circulated when it is not being supplied to the nozzles and is thus kept thoroughly mixed.

Pulling Oil-Well Casing with Air Pressure

J. R. Cozzens

A VERY important sideline of the petroleum industry is the salvage of casing from abandoned wells. Recovered casing has an average resale value of one-half the cost of new material of the same grade; but whether or not it will yield a profit depends mainly upon the cost of getting it out of the ground. It should be mentioned that the following procedure refers to casing that is not anchored in concrete at the bottom.

Casing-pulling, as it is termed in oil-field parlance, is a complicated process, requiring a mechanically powered derrick strung with wire cable and blocks of a size sufficient to withstand a lift of many tons. In order to remove a stubborn string, this power often has to be supplemented by jacks, rippers, collar-busters, and explosives, and the operator considers himself fortunate when his casing is salvaged at 20 per cent of its resale value. In the stripper oil fields of Ohio and West Virginia, where hundreds of abandoned wells are being salvaged, some very important work has been done in increasing pulling efficiency. In many districts repeated tests have taught operators that power can be reduced and pulling costs cut as much as one-third by the use of air pressure.

The amount of power necessary to release a string of casing depends upon two factors: friction between the walls of the hole and the pipe, and the vacuum or suction induced in the sludge at the bottom of the hole while the pipe is being raised. The latter factor is by far the more important one, and the air-pressure method is aimed at its correction.

The compressors generally used for the work are gasoline-driven units of the V-type construction common to oil fields; and the air is often conveyed through pipe lines a distance of a mile or more to wells that are being salvaged. Where regular stationary units are not available, portable compressors of the XL and similar types, capable of delivering air at 1,000 pounds pressure or more, are taken direct to the wells. These portable machines are generally owned by pulling crews that travel through oil and gas districts and make a specialty of well-salvaging.

The actual pulling process is conducted by erecting a derrick over a well in the usual manner. Elevators of the proper diameter are clamped around the casing top, and power is applied until a tension or lift of 3 to 5 tons is exerted upon the casing by blocks and cable. If the pipe does not yield readily at this point, the tension or strain is caught and held by means of a friction clutch upon the cable reel. A special air-tight head is quickly screwed over the casing top; pipe connections are made with the compressor; and air under pressure is forced down the casing. The pulling machinery is again started, and tension upon the cable is gradually increased.

While the lifting power upon the casing is increasing, air pressure is accumulating, pushing sludge and residue downward and pressing out pockets until it is released underneath and around the bottom rim of the casing. The vacuum or suction is destroyed instantly, and the air, now forcing its way upward and around the outside of the casing, relieves the friction. The principle is the same as that involved in opening an air valve under a vacuum jar; and in most cases the entire string of casing can be taken out with ordinary derrick power without further hindrances.

In wells containing two or more strings of casing, one inside the other, the outer or shorter strings are, of course, not settled in residue. But here, again, air pressure is a money saver on a stubborn job. After the inner casing has been removed in the manner described, a temporary bridge of quick-setting cement is made in the hole at a point a few feet below the bottom of the shorter string. Air under pressure is then applied, together with derrick power, and forces its way under the rim of the casing and upward along its outside surface. In this manner much of the friction and binding common to outside strings is relieved.

In cases of this kind, it is the practice to keep the compressor running over a longer period of time, allowing the pressure to escape or to blow out around the casing. Whenever possible, however, operators prefer to use air pressure on longer strings in which it can be confined until suction at the bottom is released, for under such circumstances the pressure serves also to test the condition of the pipe. Casing that is worth being salvaged will withstand a pressure that is high enough to loosen it. Casing that is badly rusted or corroded by mineral oxides will leak, sometimes to such an extent that it is impossible to build up sufficient force to release it. Piping in such a condition does not warrant the cost of pulling.

A string of casing loosened by air pressure comes out intact, regardless of its length or diameter, thus eliminating the need of jacks, collar-busters, or explosives. Less pulling power is required, and there invariably is a saving in labor and time. In many districts, the use of compressed air has released casing that other methods failed to salvage, thus enabling operators to recover thousands of feet of pipe that otherwise would have remained in the ground.

THEIR DAY IS DONE

An abandoned well (left) stripped of pumping equipment awaiting the casing-pulling crew; a rick of salvaged casing (below); and an abandoned oil-field power plant.

THE OIL INDUSTRY

AN ARTICLE in this issue recounts the beginnings of the petroleum industry and describes the current operations of one of the leading refiners of Pennsylvania grade crude oil. The broader significance of Edward L. Drake's momentous discovery is found, of course, in the extent to which the production of petroleum has grown throughout the world, and particularly in the United States. Since Drake's well began to yield oil, more than 21,000,000,000 barrels of petroleum have been produced in this country. A few years ago a shortage was predicted: now it is estimated that there are 17,000,000,000 barrels in our underground reserves recoverable by present methods.

The American petroleum industry employs more than 1,000,000 persons, has an annual payroll of $1,500,000,000, and pays $1,250,000,000 in taxes. In contrast to the 69-foot depth of the original well, tools are now reaching in excess of 13,000 feet into the earth to penetrate oil-bearing formations. All told, there are 360,000 active wells in our 22 oil-producing states.

In Drake's time, petroleum was desired principally for its supposed curative properties and for the illuminating oil that it yielded. The lighter products, such as gasoline, were not wanted. Today things are changed. Gasoline is the prized derivative of most petroleums; but hundreds of valuable products are regularly made. So thorough is the process of refining that nothing is thrown away from a modern plant of the type we have described.

Examples of what has been done to transform unwanted into usable products and to eliminate wastage of the lighter gases that formerly were burned or blown to atmosphere are found in the processes of cracking and polymerization. A homely but striking explanation of these operations is given by the American Petroleum Institute, which draws an analogy between them and the startling custom of Procrustes, a Greek mythological character. Procrustes had but one bed, so he made visitors fit it. If they were too long, he chopped off their feet: if they were too short, he stretched them on a rack.

Petroleum chemists, like Procrustes, found some oil molecules too large and others too small to fall within the range of gasoline. So they now cut them down or build them up to the desired size. Large molecules are broken up by cracking them under heat and pressure, while small ones are rebuilt by polymerization. By these juggling acts refiners conserve 1,000,000,000 barrels of petroleum annually—the quantity of raw stock that would otherwise have to be produced to supply the nation's gasoline requirements.

FUTURE ROADS AND CARS

THE entire science of roadbuilding has been transformed by the automobile. Many of our new highways are already obsolete because their designing engineers failed to foresee the demands that would be made upon them. Likewise, some of the roads now being constructed will be inadequate in a few years. It is no longer enough that highway designers be familiar with present needs: they must, in addition, look into the future and visualize roads that will give the kind of service that will be expected of them five, ten, or twenty years hence.

Since the changes in automobiles from year to year directly affect the roads of tomorrow, it is essential that highway planners keep abreast of motor-car developments and be able to predict future trends with a high degree of accuracy. Despite the tremendous strides that have been made in automobile design and performance, we are told that even greater improvements are to come.

In a current article, William B. Stout, former president of the Society of Automotive Engineers, stated that the airplane is pointing the way for the automobile of the future. Airplane engines, cooled by air instead of water, weigh less than 3 pounds per horsepower, as compared with 10 pounds per horsepower for automobile engines. Airplanes weigh only a fraction as much as automobiles of the same load-carrying capacity.

Various changes will come, Mr. Stout predicts, when the public demands them; and he adds that automotive engineers already are prepared to make them. Tomorrow's automobile, he says, will have its engine in the rear, thereby putting the weight where it is needed to give greater stability, easier riding, and better braking. The engine will be air-cooled and much lighter than at present. Wheel bases will be lengthened, thereby increasing riding comfort by 20 per cent; but the over-all length of cars will be less than now. Methods of springing will be altered, and the air-cushion principle will perhaps be adopted. Running boards and mudguards will be done away with, making possible greater widths and added passenger room. A strong, wide bumper will run completely around the car, giving increased protection against impact. Ventilation and heating systems will be improved, and heat-absorbing metal will be eliminated from tops and other parts that transfer the heat of the summer sun to the occupants. The resultant automobile, he believes, will be almost noiseless, will have a top speed of 70 to 80 miles an hour, and will travel 30 to 40 miles on a gallon of gasoline.

To accommodate such cars, the nation's highway system will need much modernization. Speed limits of 40 and 50 miles an hour on open roads are an admission that they are not engineered for modern automobiles. The West, Mr. Stout points out, is far ahead of the East in this respect. Some of the western states have no speed laws, and travel on their highways at 70 miles an hour is safer than under the 50-mile-an-hour allowable maximum in Pennsylvania. The East, he thinks, is paying a heavy penalty for the slowness imposed on both passenger-car and truck traffic. As soon as this is realized, straight, nonstop speedways will be constructed between the principal cities. A start in that direction has been made by the constructors of the Pennsylvania Turnpike.

This and That

Annual Report Broadcast

An innovation in publicizing annual industrial reports was introduced last month when B. C. Heacock, president of Caterpillar Tractor Company, summarized the results of the concern's 1939 business over the radio. The broadcast was made from a studio in Peoria, Ill., where the company's factory is located. Advance newspaper notices asked employees and their families to listen in. Mr. Heacock stated that he had adopted the method because he knew of no other way in which he could talk to all the 11,000 employees in a group. The broadcast consumed half an hour. In addition, the annual report was also made available to employees and stockholders in the form of a 24-page booklet.

* * *

Curbing Vibration Breakage

Vibrating machinery may cause various kinds of trouble. One of the most serious types is broken pipes and other connections. In such instances, the vibration is sufficient to cause crystallization in the metal that results in early fracture at the point of connection. It has been found that breakage of this kind most commonly occurs in connections that are made too high. The best remedy is to make the connection at a point as near the foundation as is practicable. The explanation is that the amplitude of vibration is always least at the foundation and greatest in the parts of the machine that are farthest above the foundation. The principle is precisely the same as in a tuning fork. The logical place for connecting pipes, cables, ducts, etc., is, accordingly, near the floor. This applies also to flexible types of connectors made especially to resist vibration, whether metallic or nonmetallic, because even they have their bending limitations.

* * *

Industrial Tires Increase

The use of rubber tires on small industrial trucks and trailers nearly doubled in 1939, when sales went above the half-million mark for the first time. The growing tendency to cushion the wheels that move goods within factories, on piers, and elsewhere, has been accompanied by increasing specialization in industrial tires, and they are now available in widely diversified forms. The pneumatic type leads, but solid tires and a newly introduced "cushion" type also are popular. In the case of the latter, the air space is filled with a resilient stock that eliminates punctures and valve leaks. The B. F. Goodrich Company has recently developed an oilproof tire for service where floors are oily. More than 60 per cent of the industrial tires now sold are for new vehicles which means that rubber manufacturers still have a big potential market to shoot at. It is estimated that there are 10,430,000 vehicles in use in factories, warehouses, and terminals, the number of wheels on each ranging from two to six. Solid-rubber tires for this sort of service were introduced around 1910, while the pneumatic type made its appearance about ten years ago.

* * *

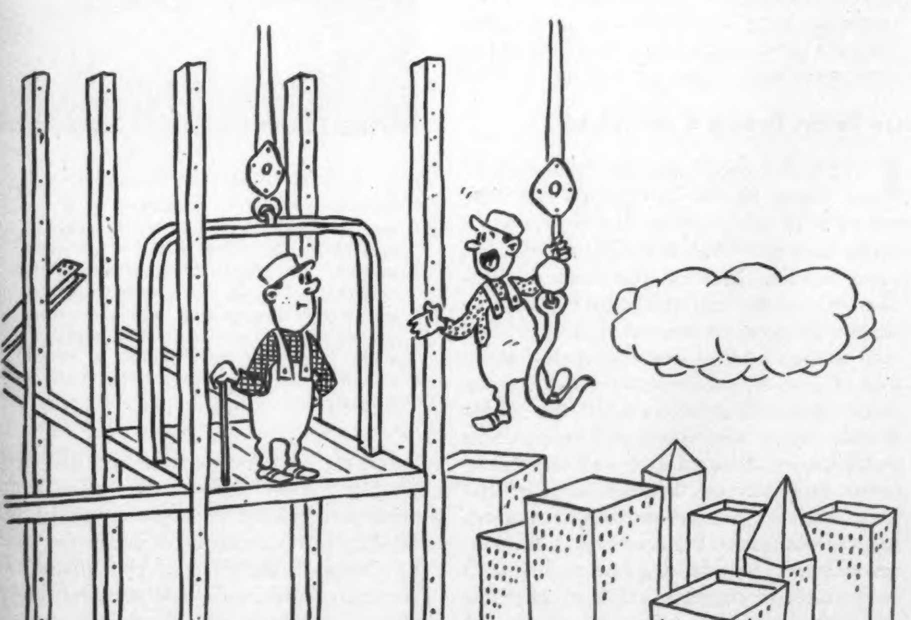
"ene" or "ine"

Although Webster and some other authorities give "kerosene" as the correct spelling of that well-known word, the American Petroleum Institute is leading a campaign to spell it "kerosine." The American Society of Testing Materials and a few publications concur in this orthography—the advocates of "ine" pointing out that kerosine, benzine, and gasoline are all coined words that have no strict chemical meaning, whereas the "ene" termination in toluene, benzene, etc., denotes a definite chemical compound. It is just as logical to write "gasolene" as it is "kerosene," and one of the large dispensers of these fluids does use the suffix "ene" in both words. A large part of the motoring public shows its unconcern by ignoring the ending in gasoline and calling it simply "gas." Perhaps the issue could likewise be neatly sidestepped in the case of kerosene or kerosine by reviving its time-honored name—coal oil.

* * *

Better Weather Reports

The prospect that scientists will soon be able to make accurate long-range weather forecasts is of interest to everyone, and especially to dealers in fuel. It will enable coal producers to gauge their output so as to meet the demand and to prevent shortages and surpluses. This applies also to fuel-oil producers. In 1939, house-heating burners used 4,000,000,000 gallons of oil. The day-to-day requirement depends on weather conditions and may fluctuate widely. In January of this year, the prolonged cold spell sent the consumption up as much as 50 per cent in some sections of the country. The major oil companies and their distributors watch thermometers closely and can tell by the temperature just how fast customers are burning oil and when they will need more. They cannot, however, at the present time foretell seasonal requirements. In 1938 there was a 10 per cent increase in domestic oil burners, and the industry therefore provided stocks of oil 10 per cent greater than those consumed in 1937. But, as it turned out, the weather was 10 per cent warmer than during the previous year, and a surplus of fuel oil resulted. With long-range weather forecasting an accomplished fact, then refinery runs can be gauged to meet the demand.



"I'll meet you on the street. I get dizzy when I ride elevators."

New Method of Bonding Soft Rubber to Metal

AFTER several years of research and experimentation, the Hewitt Rubber Corporation has developed a method of bonding soft rubber and Neoprene to steel and aluminum by hot vulcanization. The process by which the rubber is attached to the metal is called Dura-Bond. It is said to be of a chemical nature and to modify the composition of the rubber so that it becomes an integral part of the underlying material while at the same time retaining its capacity to vulcanize itself to the outer Neoprene layer. The strength of adhesion between the rubber and the metal ranges from 500 to 750 pounds per square inch.

RUBBER BLANKETED

This large cylinder was made for the pickling-bath division of a steel company and has a coat of rubber, 1-inch thick, applied by the Dura-Bond process. For this particular purpose, the rubber was compounded to resist acid solutions, cuttings, and the abrasive action of metal passing over the roll at high speeds. The picture shows the finishing or grinding-down operation, which was done at the rate of 5/1,000 inch of rubber at a time.

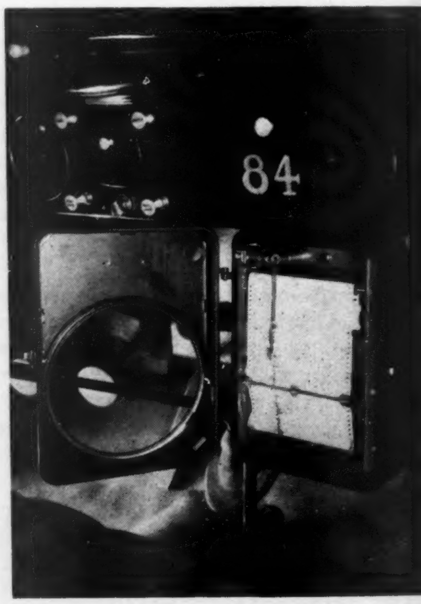
The products are resistant to abrasion and corrosion, and combine the sound-damping qualities of rubber with the durability and rigidity of metal. They can be subjected to a maximum temperature of 200°F., although efforts are being made to increase this to at least 250°.

Because of this combination of qualities, metal protected by the Dura-Bond method is finding increasing application in the transportation and mechanical-goods industries. The process is also being used to coat sheet metal, the built-in nipples of oil suction and discharge hose, and steel and aluminum rolls. In the latter case it proves especially effective, as the firm bond prevents slippage, which heretofore has been somewhat of a problem with rubber-covered cylinders. Of those produced by the Hewitt Corporation, the largest one was also the first one to be treated by the Dura-Bond process. It is shown in the accompanying illustration and is 77 inches long and 24 inches in diameter. There is a layer of rubber 1-inch thick on the main body of the roll, and the cylinder ends as well as adjoining sections of the shafts are likewise coated. With the equipment now available it is possible to bond soft rubber to metal rolls up to 2 feet in diameter, together with a 1½-foot section of shaft on each side, thus eliminating the use of a hard-rubber base or plating the metal with brass.

Instrument Detects Bumps in Concrete Roads

"BUMPING ALONG" is an expression of which most of us know the meaning. In order that we may determine just how much we bump along in our automobiles, or how smooth the roads are over which we travel, The Dow Chemical Company has devised a recording instrument that it calls the Rufometer. It is mounted under the cowl of a car to the right of the driver, and measures and registers the bpm., or bumps per mile. It was developed primarily to enable the Dowflake Road Research Department to determine the relative roughness of untreated loose gravel roads and those treated with Dowflake calcium chloride. However, as the data furnished is of vital concern to the highway construction and maintenance engineer, not to mention the traveling public, the former will undoubtedly put the instrument to use.

The Rufometer translates the vertical motion of a car into oscillating motion, and causes a pen to record on a chart the actual bumps per mile. The pen is about 6 inches long, and moves either to the right or to the left of a neutral point in direct proportion to the vertical displacement of the car body. The strip chart is 6 inches wide, and is wound through the medium of a drive roll and gear train by a power take-off from the speedometer cable. It can be run at the rate of 2½ inches per mile or 25 inches per mile, the change being effected by shifting the gear train. With landmarks such as bridges, railroad crossings, and road intersections recorded in their proper places, together with notes made by the operator during the test, the chart is marked off in mile sections and blueprinted or photostated for convenient study.



A BUMP RECORDER

This instrument is connected by a system of links to the lower knee-action arm of the left front wheel of an automobile. As the car travels along, the vertical motion of the arm is translated into oscillating motion which is transmitted through the medium of shafts to a pen which, in turn, makes a visible record of the roughness of the road on a chart.

Magnet Removes Tramp Iron from Concrete

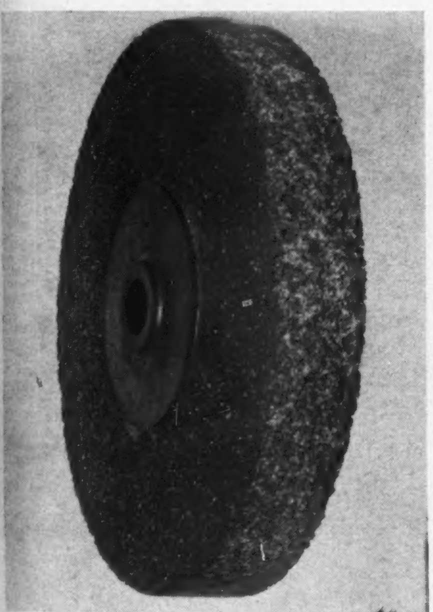
IT'S PICKED UP A BOLT

IN LINING the 2-mile Des Plaines Avenue water tunnel in Chicago, Ill., the concrete is delivered to the forms by a screw conveyor that is fed by a belt conveyor leading back to the mixers. Suspended over the belt at a point close to the screw conveyor is a magnet that was called into service when it was found that stray bits of iron in the concrete—small nails, track nuts and bolts—jammed the blades of the screw and hampered operations. Bolts caused most of the trouble, and in order to determine whether or not the magnet would give satisfaction, it was put to an initial test by burying twelve of them, marked for identification, from 2½ to 3 inches deep in the mass. The magnet did not miss one; and it is now in regular use and removing around 10 pounds of tramp iron daily from the concrete. It is of the rectangular type suitable for belt conveyors, and was built by the Dings Magnetic Separator Company.

Industrial Notes

Motor vans with doors that roll up and out of the way beneath the top are an improvement over those that are hinged and open out, because they permit backing the vehicles against the loading platforms. The doors are constructed of steel slats and are counterweighted so that they will remain open or closed until moved by hand.

What is claimed to be a really satisfactory resilient bushing for the wheels of different types of portable grinders has been developed by The Manhattan Rubber Mfg. Division of Raybestos-Manhattan, Inc. It is a split, rubber bushing each half of which has a flange and a bead underneath the flange. When both are inserted in the hole of the grinding wheel, the metal flanges of the tool are drawn up by the spindle nut. This forces the resilient flanges, which are slightly larger in diameter than the metal ones, tight against the sides of the wheel and compresses the bead so that the bushing itself is brought in intimate contact with the spindle and the wheel. The result



is a wheel that is said to be properly centered and so mounted that there is not sufficient give to throw it out of round in operation. This, together with less vibration, makes for a smoother-working tool that enables the operator to guide the wheel with greater ease and accuracy—to do a good job with less effort. In its present form, the Vibration Dampener Bushing, or V.D.B. for short, is designed for straight, not cup-shaped, wheels of 6-8 inches in diameter. It is not intended for rigidly mounted wheels of larger size making fewer revolutions a minute.

A new 1- to 2-inch ratchet pipe threader that operates on the receding-die principle has been placed on the market by The Toledo Pipe Threading Machine Company. The tool is clamped quickly and positively on to the pipe by three heavy thumb screws and bushings, and there is a separate set of four dies for each size of pipe. These dies are held firmly each in its own slot, where it is supported by a retaining spring and

backed by a hardened-steel taper pin, as the illustration shows. This arrangement prevents spreading and permits adjustments for oversize, undersize, and standard threads to be made with equal facility. It is claimed that the tool will easily cut threads that are free from waves and that will assure tight joints. The assembly, including a tubular steel handle 24 inches long, weighs 17 pounds.

Stainless steel containing less than 1 per cent of silver is being sold under the trade name of Silver Stainless. The material is the product of Chemical Foundation, Inc., and is available in cast, drawn, forged, and rolled form. It is said to be resistant to pit corrosion, to be a good conductor of heat and to machine readily. License to manufacture it can be obtained from the company.

It is reported from Argentina that the railway tunnel through the Andes connecting that country with Chile will be altered to accommodate automobile traffic. There is sufficient room on one side of the tracks for a narrow road which is soon to be undertaken and which is to serve the motoring public until the proposed 5-mile tunnel for the Pan-American Highway has been cut through that mountain range.

The Chicago Belting Company, which has 50 years of successful business behind it, has recently published a book on *Hydraulic and Pneumatic Leather Packing Design and Application* that should prove of value because the subject is one that is not dealt with in handbooks. It is profusely illustrated with sketches, and covers every phase of these packings—the leather of which they are made, the different types, their design and application, problems encountered and how to cope with them, what not to do, etc. Furthermore, it contains what is said to be the first compilation of standards for leather packing ever presented. The book is copyrighted, and is available for free distribution only to heads of engineering departments and designing engineers in industrial plants using packings either for replacement or for standard equipment. Applications should be directed to Green and Washington Streets, Chicago, Ill.

Under the name of Serviceman, the James P. Marsh Corporation is offering a vapor-tension thermometer of pocket size. The housing has a hinged door on the inner side of which is a stationary drum. On this the capillary tubing with the temperature-sensitive element is wound when not in use. The instrument comes in two standard sizes giving readings between −10 and +65 or +100°F., but the company is also prepared to furnish thermometers of this type with calibrations between −20 and +40 or +65.

Strangl-Hold is the name of a new adhesive that is said to have exceptional bonding properties. It consists of a powder and a liquid which are mixed before application. Some of the claims made for it are that it will retain its adhesiveness for years—will not dry, crack, or pull away, and that it is resistant to extreme changes in temperature and many corrosives. It is suitable for all kinds of materials, including metal, glass, wood, paper, fabrics, leather, etc., and can be used as a primer for paint, especially where protection against corrosion is desired.

For the removal of defective vitreous enamel from steel sheets, Michigan Products Company has designed a sand-blast gun that is said to leave the metal sufficiently clean so that it can be reënameled without further preparation. The distinctive feature of the apparatus is the nozzle, which has five outlets arranged in a straight line

to deliver a flat blast that lifts the enamel from thin sheets without peening or distorting them. Silica sand that will pass through a 40-mesh screen is recommended for the service, and is applied with air at a pressure of from 40 to 80 pounds per square inch. The gun is also suitable for cleaning stone, wood, and other surfaces that a harsher, single-blast nozzle might damage. In the accompanying picture it is removing an unsatisfactory coat of enamel from a sink.

Electric cable with a protective covering of specially compounded rubber is a flexible heating unit that is said to serve many useful purposes in winter. It can be used to break the grip of frozen soil or other materials, can be immersed in water to prevent it from freezing, and can be wrapped around exposed pipes, valves, etc., to thaw them out or loosen them. The cable is about 1/8 inch in diameter, is furnished in lengths ranging from 60 to 1,000 feet, and takes current of 120 to 220 volts. It was initially developed for service in greenhouses.

Will air-conditioned blast furnaces produce better pig iron is a question that the Woodward Iron Company of Alabama is attempting to answer. For the purpose of the experiments, a blast furnace has been modernized and provided with a refrigeration and air-conditioning system that will cool 2,700 tons of air a day to a constant, predetermined dew point and remove from it 20 tons of water. The treated air is subsequently heated to a temperature of 1,000°F. The object, of course, is to control the amount of moisture in the air and thus to produce pig iron of greater uniformity.

In building the Genissiat Dam in a deep and rocky gorge in the River Rhone, the engineers sealed the cofferdams and solidified the foundation by the use of two different bonding methods one of which was worked out for the purpose in the laboratories of the Departement des Travaux Publics. With the steel sheet piling in place, it had been planned to grout the sands and gravels overlying the rock bottom in the ordinary way; but tests proved that cement would not do. The Joosten process of silification, now extensively used abroad to compact loose soils, was satisfactory; but in view of the area involved would have been too costly. Therefore, "In order to limit the zone of silification," to quote *The Engineer*, "two vertical planes, one immediately above and the other below the steel piles have been injected with clay under a pressure of 9 to 11 kilos. (19.84 to 24.25 pounds) per square centimeter (0.155 square inch) and will form screens between which the sands and gravels will afterwards be solidified by silification. The average absorption of the clay has been found to be 2.4 kilos. (5.3 pounds) per square meter (1.196 square yard) of the curtain."